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IN THIS ISSUE

ALTHOUGH published observations of weight and length of infants are common, reports of serial observations for other body measurements during infancy are less frequent. An addition to the literature of the latter type is the fifth of the series of Newborn Studies from the Nutrition Clinic of the Philadelphia Lying-In Hospital, entitled "Size and Growth of Babies During the First Year of Life." This report summarizes the measurements made on a group of infants at birth, and three, six, and twelve months of age for chest circumference, crown-rump length, rump-sole length, hip breadth, head circumference, and calf circumference, as well as weight and crown-sole length. Both the mean values of these measurements and the average increments for each measurement between each age are presented, as well as the correlations between the measurements and between the increments.

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The report on "The Influence of War and Post-war Conditions on the Teeth of Norwegian School Children" is concluded in this *Quarterly* with publication of Part III "Discussion of Food Supply and Dental Condition in Norway and Other European Countries." Dr. Guttorm Toverud, Professor of Pedodontia at the State Dental School, who directed extensive dental studies in Norway from 1940 to 1953 and presented data on changes in dental condition of school children during these years in Parts I and II, now reviews changes in the food supply in Norway and discusses the interrelationship between kinds of foods consumed and the frequency of caries. Although the small consumption of sugar is stressed as a causal factor

in the reduction of caries, Dr. Toverud presents evidence that an increased resistance to caries acted as a second factor in reducing caries during the War.

In addition to describing the food situation and dental condition in Norway, Dr. Toverud has summarized the reports on similar studies in other European countries and reviewed the various interpretations of the causes of changes in the frequency of caries which occurred in most European countries.

MATERNAL AND NEWBORN NUTRITION STUDIES AT PHILADELPHIA LYING-IN HOSPITAL*

NEWBORN STUDIES. V. SIZE AND GROWTH OF BABIES DURING THE FIRST YEAR OF LIFE

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DURING the course of the Nutrition Study at the Pennsylvania Hospital, physical examinations were routinely done on the infants in the study population. These examinations were performed on the newborn infants within a few days of birth and, subsequently, at ages one, two, three, six, and twelve months. The examination procedure included determination of weight and measurement of the baby's chest circumference, crown-sole length, crown-rump length, hip breadth, head circumference, and calf circumference. The analysis of the data on weight, crown-sole length, and chest circumference for the examinations up to three months of age have been presented in another paper in this series of Newborn Studies (1), and this paper will report on all measurements made at birth and at three, six, and twelve months of age.

The analysis is based on the records of 1,391 singleton infants, weighing more than 5.5 lbs. at birth, whose mothers attended the Nutrition Clinic during the years 1947–1952. Babies of mothers with syphilis or a serious chronic disease have not been included.[4] Three hundred and fifty-four of the

* The Nutrition Studies at Pennsylvania Hospital (Philadelphia Lying-In Hospital) were supported by grants-in-aid from the Milbank Memorial Fund, the Williams-Waterman Fund, the National Vitamin Foundation, the Upjohn Company, E. R. Squibb and Sons, and in part by the Nutrition Foundation and Mead Johnson & Company.

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[4] Patients with chronic disease or syphilis referred to the Nutrition Research Clinic were carried but have been excluded from tabulations in this report. Chronic diseases excluded are essential hypertension, chronic heart classified II-a or higher, chronic nephritis, and chronic pyelitis.

babies were Negro, and the remaining 1,037 were white, of whom about 75 per cent had one or both parents of Italian ancestry. All infants were on the same regimen in the Hospital, and the mothers were given uniform diet instructions and vitamin supplements for their babies. The condition of the infants was generally appraised as favorable by the pediatricians, only 3 per cent being rated as poor at birth.

The babies were not always returned to the Clinic for each scheduled examination and the number for whom observations are available decreases considerably after the birth examination. This attrition is especially heavy among the group of white infants. Weight was determined on almost all of the individual examinations, but it was not always possible to make all of the other measurements so that there are differences in the numbers on which the analysis of each measurement is based. Measurement of calf circumference was not included in the examination until the later part of the program, and there are fewer observations of this dimension than there are of the other measurements.

In most cases, the examinations were not done at exactly three, six, and twelve months of age. The observations were adjusted to these ages by plotting the measurements for each baby and making a linear interpolation or extrapolation from the date of examination to the date on which it should have been done. This method was not used to estimate missing observations when no examination had been performed.

During much of the study the measurements were made by one pediatrician (A.R.).[5] The procedure for each measurement is as follows:

Weight: The infants were weighed nude on a scale measuring in pounds and ounces, and the weight was read to the nearest ounce.

Chest Circumference: Measured with a steel tape in centimeters

[5] Measurements not done by Alexander Randall, IV, M.D., were done by Josephine Perlingiero Randall, M.D., and Thomas R. Boggs, M.D.

to the nearest tenth at the level of the xiphoid normal to the body axis.

Crown-Sole Length: With the baby placed flat and straight on a board, the measurement was made from the plane tangent to the top of the head to the bottom of the heels, and read in centimeters to the nearest tenth.

Crown-Rump Length: Measured between the planes tangent to the top of the head and the bottom of the buttocks when the infant was lying on his back on the measuring board with the legs flexed on the abdomen.

Rump-Sole Length: Computed by subtracting the crown-rump length from the crown-sole length.

Hip Breadth: Measured with sliding steel calipers, graduated in millimeters, at the maximum breadth between the iliac crests.

Head Circumference: Measured approximately around the crown at the greatest circumference in this area with a steel tape and read to the nearest tenth of a centimeter.

Calf Circumference: Measured with a steel tape at the maximum circumference of the calf, and read to the nearest tenth of a centimeter.

The purpose of the Nutrition Study was to assess the effect of nutrient supplements in the diets of pregnant women upon the outcome of pregnancy and the physical status of the infant. The latter question has been reported upon in earlier papers in this series (2) (3), based upon the examination of the infants at birth and one month of age. It was concluded that the effect of the supplements upon the physical condition of the infant was slight. It was believed that if no action of the supplements was apparent during the first month of life, none would appear later. However, the observations at the later ages during the first year of life were analyzed to see whether the supplements seemed to influence the size and growth of the infants, but no such association was found. In view of these negative results, the extensive data for this analysis will not be presented in this report.

Table 1. Mean and quartile values of weight by age and by race and sex.

Race and Sex	Mean (lbs.)				Standard Deviation				Number			
Section A	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White Males	7.53	13.45	18.05	23.47	.96	1.58	2.00	2.77	569	265	238	134
White Females	7.26	12.42	16.72	21.68	.89	1.29	1.86	2.59	468	248	212	122
Negro Males	7.38	13.49	17.67	22.76	1.02	1.41	2.05	2.77	185	151	141	92
Negro Females	7.15	12.43	16.46	21.42	.95	1.60	2.08	2.87	169	130	120	84

	Difference in Means				Ratio of Means			
Section B	Male Minus Female				$\left(\frac{\text{Male}}{\text{Female}}\right) \cdot 100$			
	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White	.27	1.03	1.33	1.79	103.7	108.3	108.0	108.3
Negro	.23	1.06	1.21	1.34	103.2	108.5	107.4	106.3
	White Minus Negro				$\left(\frac{\text{White}}{\text{Negro}}\right) \cdot 100$			
Male	.15	−.04	.38	.71	102.0	99.7	102.2	103.1
Female	.11	−.01	.26	.26	101.5	99.9	101.6	101.2

	Quartile Values (lbs.)											
Section C	Birth			3 Months			6 Months			12 Months		
	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile
White Males	6.87	7.59	8.26	12.38	13.46	14.51	16.61	17.90	19.41	21.65	23.52	25.25
White Females	6.67	7.30	7.93	11.49	12.33	13.22	15.40	16.54	17.78	20.01	20.89	23.32
Negro Males	6.67	7.39	8.22	12.49	13.41	14.39	16.27	17.58	18.91	21.00	22.41	24.29
Negro Females	6.47	7.11	7.86	11.20	12.44	13.60	14.93	16.44	17.68	19.36	21.40	23.00

Measurements at Each Age

The observations at birth and three, six, and twelve months of age are summarized in Tables 1–8 and Figures 1–8. One table and figure is devoted to each measurement and each table is divided into three sections. In Section A are given the means and standard deviations for each of the four race-sex groups; Section B shows the differences in the means by race and by sex and the ratios of the means of male infants to those for females and the ratios of the means for whites to those for Negroes; in Section C are the quartile values for each distribution of the observations by race and sex.

Weight (Table I and Figure 1). The average birth weights

Fig. 1. Mean and quartile values of weight by age and by race and sex.

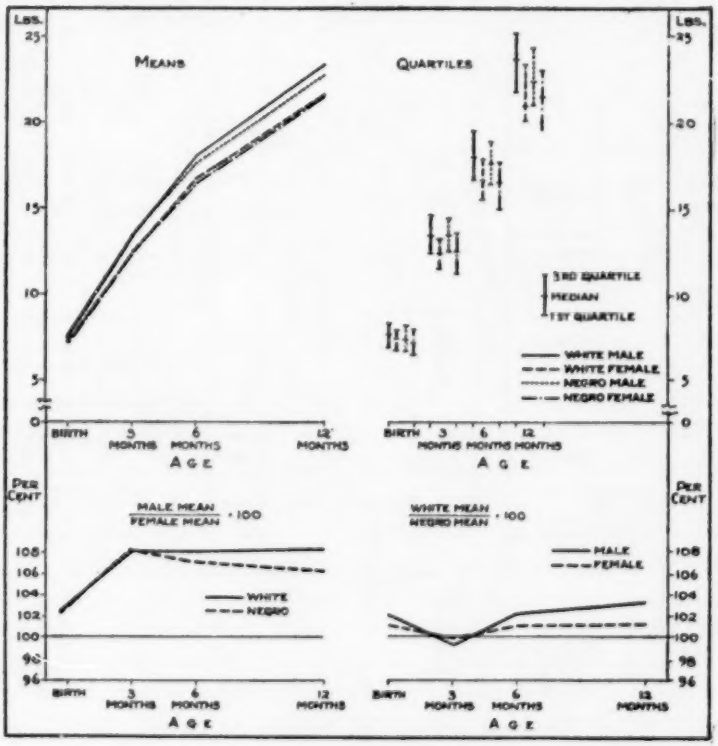

Table 2. Mean and quartile values of chest circumference by age and by race and sex.

Race and Sex	Mean (cms.)				Standard Deviation				Number			
Section A	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White Males	32.60	41.01	44.73	48.71	1.67	1.78	1.84	2.21	508	265	232	130
White Females	32.25	39.78	43.50	46.86	1.55	1.63	1.82	2.12	406	247	211	121
Negro Males	32.01	40.67	44.14	47.51	1.85	1.71	1.88	2.14	161	151	137	91
Negro Females	31.89	39.45	42.93	46.21	1.68	1.79	2.05	2.30	148	129	115	82

	Difference in Means				Ratio of Means			
Section B	Male Minus Female				$\left(\frac{\text{Male}}{\text{Female}}\right) \cdot 100$			
	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White	.35	1.23	1.23	1.85	101.1	103.1	102.8	103.9
Negro	.12	1.22	1.21	1.30	100.4	103.1	102.8	102.8
	White Minus Negro				$\left(\frac{\text{White}}{\text{Negro}}\right) \cdot 100$			
Male	.59	.34	.59	1.20	101.8	100.8	101.3	102.5
Female	.36	.33	.57	.65	101.1	100.8	101.3	101.4

	Quartile Values (cms.)											
Section C	Birth			3 Months			6 Months			12 Months		
	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile
White Males	31.36	32.59	33.83	39.74	40.91	42.21	43.43	44.76	45.84	47.20	48.70	50.26
White Females	31.16	32.18	33.34	38.70	39.79	40.89	42.22	43.40	44.65	45.22	46.86	48.59
Negro Males	30.64	31.92	33.34	39.57	40.62	41.82	42.77	43.86	45.51	46.04	47.21	49.13
Negro Females	30.82	31.79	33.19	38.29	39.46	40.63	41.31	43.27	44.41	44.61	46.18	48.04

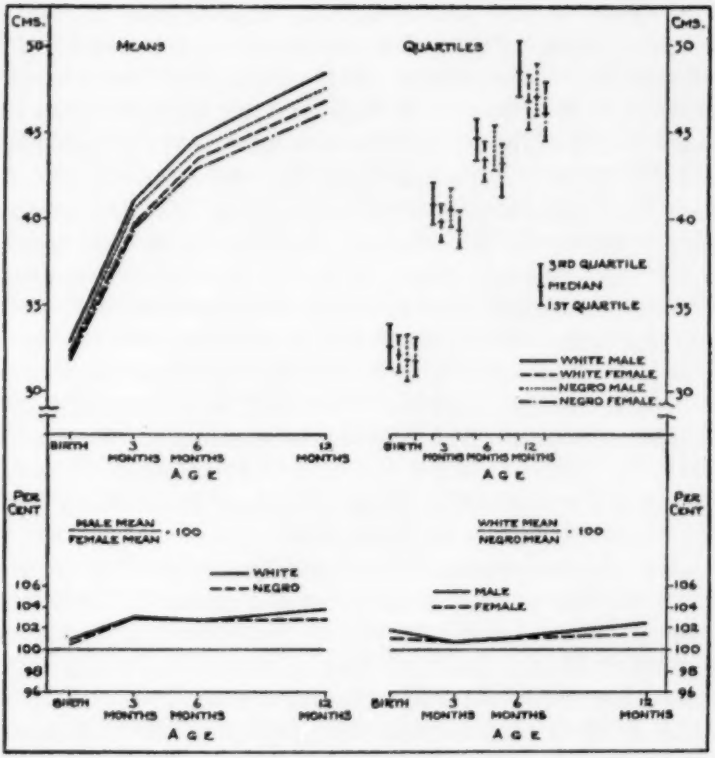

Fig. 2. Mean and quartile values of chest circumference by age and by race and sex.

for the four groups of babies range from 7.15 lbs. for Negro females to 7.53 for white males. At three months of age the means fall between 12.4 and 13.5 lbs., at six months between approximately 16.5 and 18.0 lbs., and at twelve months between 21.4 and 23.5 lbs. The average weight of male infants is greater than that of females at all four observations during the first year of life. At birth the means for the male groups are about .25 lbs. above those for females; at three months the difference is over 1 lb. and at twelve months of age it is 1.79 lbs. for the white babies and 1.34 lbs for the Negroes. In relative terms, the mean weight for males is about 3 per cent

greater than that for females at birth, the differential increasing to 8 per cent at three months and remaining between 6 and 8 per cent for the subsequent observations. The mean weight for white infants tends to be slightly larger than the mean for Negro infants of the same sex at each age except three months. This difference at birth is under .2 lbs. and at twelve months is almost .75 lbs. for males and .26 for females. At three months there is practically no difference between the average weight of white and Negro babies of the same sex. The corresponding differences expressed as a per cent of the means for Negroes are 2–3 per cent for males and 1–2 per cent for females. Study of the quartile values, illustrate the tendency of heavier weights in male infants and the relatively smaller differences in weight by race. At each of the four points of observation the quartile values for males are larger than the corresponding values for females of the same race. These differences are small at birth but emerge clearly at the later ages.

Chest Circumference (Table 2 and Figure 2). At birth the means of chest circumference in the four groups of babies are between 31.9 and 32.6 cms. and at twelve months they vary between 46.21 cms. for Negro females and 48.71 cms. for white males. The means for males are larger than those for females except at birth when the mean for white females (32.25 cms.) exceeds that for Negro males (32.01 cms.). At the examinations at three months and after, the average chest circumference for males is well over 1 cm. above that for females of the same race, corresponding to a percentage difference of about 3 per cent. The means for white babies are consistently larger than those for Negro infants of the same sex, but, except for males at twelve months the differences lie between .3 and .7 cms. The quartile values indicate that at birth the white males tend toward a larger chest circumference, with little difference among the other three groups. At the later observation periods, the occurrence of larger measurements among the males is evident.

Crown-Sole Length (Table 3 and Figure 3). Crown-sole

length of male infants averages about 50.2 cms. at birth, slightly above 61 cms. at three months, 67.9 cms, at six months, and about 76.8 cms. at twelve months. The corresponding values for females are around 49.5 cms. at birth, just under 60 cms. at three months, 66.2 cms. at six months and 74.8 cms. for white females and 75.6 cms. for Negro females at twelve months. Thus at birth the mean length of males is .7 cms. greater than that for females, and at the later periods this difference ranges from 1.2 cms. to 1.9 cms. These represent differences of between 1.5 and 2.7 per cent of the means for females. The differences in the mean crown-sole lengths by race are generally small and inconsistent with respect to sign. From birth onward, the differences by sex in the distributions of the measurements of length and the negligible variation by race are reflected in the quartile values.

Crown-Rump Length (Table 4 and Figure 4). The pattern of the distributions of this segment of crown-sole length, resembles that noted for the latter measurement with respect to the differences by sex but not by race. As was also found for crown-sole length, the mean crown-rump length for males is consistently greater than that for females of the same race, although in relative terms the differences for crown-rump length are not as large. At birth, the means for males exceed those for females by less than 1 per cent, and for the Negro group the difference never exceeds 2 per cent, while it rises to 2.5 per cent for the white infants. The white babies have average crown-rump lengths which are always higher than those for Negroes of the same sex, but the difference is never as large as 1 cm. These are equivalent to percentage differences of between .4 and 1.8 per cent. Thus, while there appears to be no difference in crown-sole length by race, the white babies tend toward a slightly larger crown-rump length than do the Negroes. This may also be seen in the graph of the quartile values.

Rump-Sole Length (Table 5 and Figure 5). The factors of race and sex evidently influence this segment of the total body length to a greater extent than they do the crown-rump length.

Table 3. Mean and quartile values of crown-sole length by age and by race and sex.

Race and Sex	Mean (cms.)				Standard Deviation				Number			
Section A	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White Males	50.30	61.03	67.89	76.75	2.08	2.22	2.48	2.71	513	264	234	131
White Females	49.61	59.88	66.26	74.83	1.92	2.15	2.28	2.55	403	247	212	124
Negro Males	50.12	61.19	67.90	76.87	2.15	2.07	2.33	2.57	162	152	138	91
Negro Females	49.40	59.98	66.14	75.60	1.87	2.27	2.39	2.82	149	129	119	82

Section B	Difference in Means: Male Minus Female				Ratio of Means: $\left(\frac{\text{Male}}{\text{Female}}\right) \cdot 100$			
	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White	.69	1.15	1.63	1.92	101.4	101.9	102.5	102.6
Negro	.72	1.21	1.76	1.27	101.5	102.0	102.7	101.7
	White Minus Negro				$\left(\frac{\text{White}}{\text{Negro}}\right) \cdot 100$			
Male	.18	−.16	−.01	−.12	100.4	99.7	100.0	99.8
Female	.21	−.10	.12	−.77	100.4	99.8	100.2	99.0

Section C	Quartile Values (cms.)											
	Birth			3 Months			6 Months			12 Months		
	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile
White Males	48.93	50.28	51.66	59.60	60.79	62.63	66.17	67.70	69.58	74.92	76.78	78.45
White Females	48.36	49.59	50.85	58.40	59.74	61.34	64.57	66.18	67.83	73.05	74.71	76.58
Negro Males	48.66	50.25	51.59	59.69	61.39	62.61	66.16	67.76	69.58	75.28	77.09	78.69
Negro Females	48.09	49.17	50.68	58.49	60.08	61.20	64.73	66.09	67.40	73.72	75.54	77.35

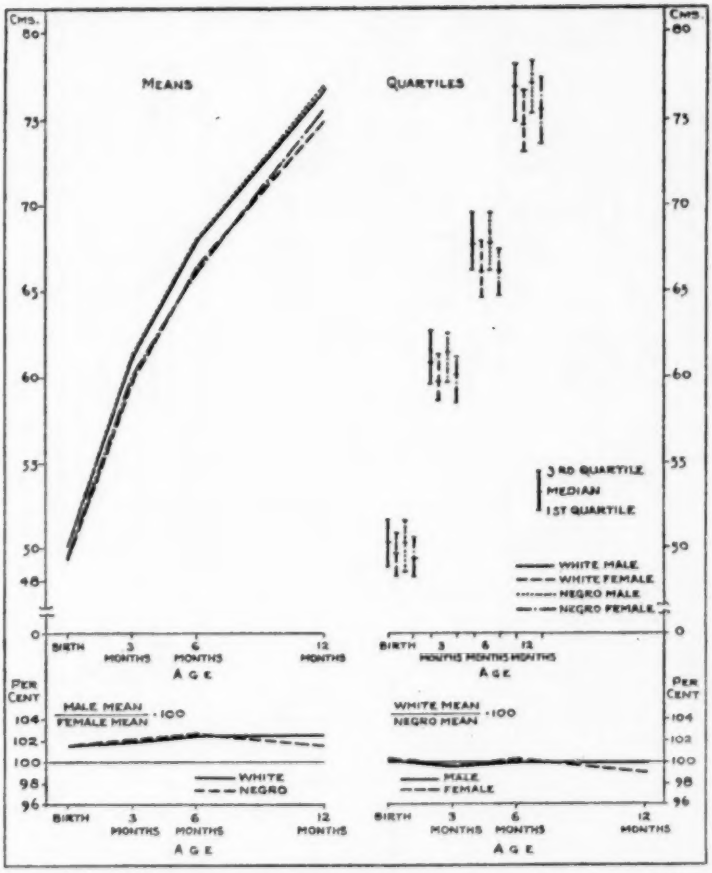

Fig. 3. Mean and quartile values of crown-sole length by age and by race and sex.

The means of this dimension for males are greater than those for females by about 2 per cent among white infants and between 2 and 3.5 per cent among Negroes. Rump-sole length is one of the measurements for which the means for Negro babies are greater than those for the white infants of the same sex. At birth, the average rump-sole length for Negroes is greater than that for whites by .25 cms. for males and .18 cms. for females and this differential steadily increases until at

Table 4. Mean and quartile values of crown-rump length by age and by race and sex.

Race and Sex	Mean (cms.)				Standard Deviation				Number			
Section A	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White Males	34.01	41.12	45.23	49.48	1.48	1.57	1.63	1.84	411	238	215	124
White Females	33.68	40.39	44.31	48.28	1.32	1.42	1.57	1.77	327	203	181	111
Negro Males	33.44	40.73	44.66	48.60	1.47	1.40	1.71	1.87	142	126	123	82
Negro Females	33.32	40.21	43.86	47.88	1.46	1.63	1.74	2.08	130	108	102	74

	Difference in Means				Ratio of Means			
Section B	Male Minus Female				$\left(\frac{\text{Male}}{\text{Female}}\right) \cdot 100$			
	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White	.33	.73	.92	1.20	101.0	101.8	102.1	102.5
Negro	.12	.52	.80	.72	100.4	101.3	101.8	101.5
	White Minus Negro				$\left(\frac{\text{White}}{\text{Negro}}\right) \cdot 100$			
Male	.57	.39	.57	.88	101.7	101.0	101.3	101.8
Female	.36	.18	.45	.40	101.1	100.4	101.0	100.8

	Quartile Values (cms.)											
Section C	Birth			3 Months			6 Months			12 Months		
	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile
White Males	32.95	33.99	35.04	40.09	41.08	42.16	44.14	45.14	46.39	48.18	49.61	50.74
White Females	32.79	33.68	34.61	39.43	40.37	41.30	43.30	44.28	45.28	47.11	48.21	49.51
Negro Males	32.43	33.53	34.53	39.67	40.58	41.69	43.36	44.62	45.85	47.26	48.53	49.84
Negro Females	32.23	33.23	34.25	39.12	40.17	41.33	42.78	43.73	45.04	46.37	47.64	49.31

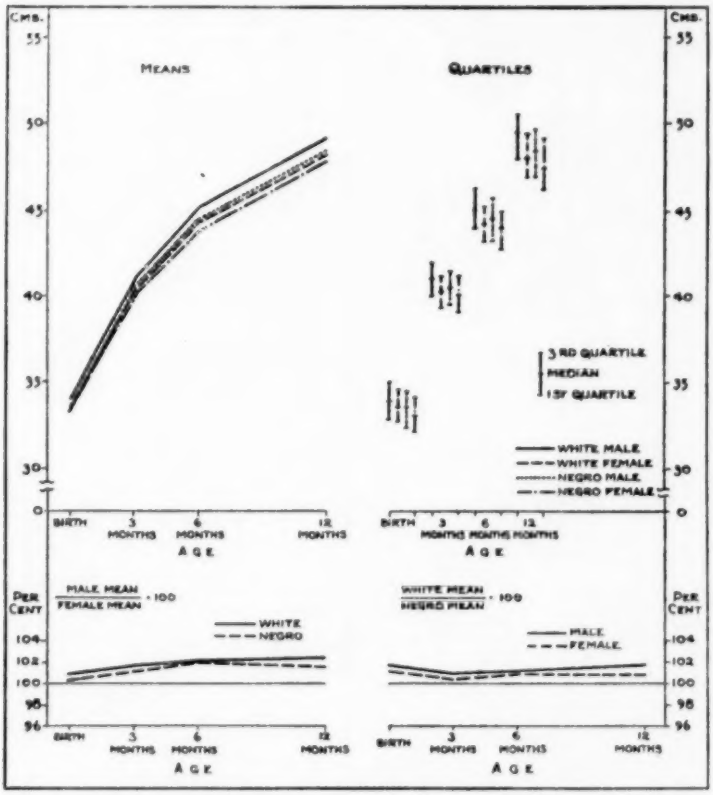

Fig. 4. Mean and quartile values of crown-rump length by age and by race and sex.

twelve months the difference is about 1.1 cms. At birth, the mean for white babies is less than 99 per cent of the corresponding mean for Negroes and at the end of the first year it is only 96 per cent of the average among the Negro infants. The largest quartile values are observed for Negro males, and at birth, three and six months, these values are about equal among the white males and the Negro females. At twelve months of age the quartile values for both Negro populations are larger than those for the white babies.

The longer rump-sole length and shorter crown-rump length

Table 5. Mean and quartile values of rump-sole length by age and by race and sex.

Race and Sex	Mean (cms.)				Standard Deviation				Number			
Section A	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White Males	16.37	20.00	22.73	27.30	.98	1.20	1.34	1.64	411	237	215	124
White Females	16.03	19.63	22.19	26.79	1.02	1.21	1.31	1.51	327	203	181	111
Negro Males	16.62	20.59	23.39	28.41	.94	1.14	1.49	1.53	142	126	123	82
Negro Females	16.21	19.97	22.60	27.86	.99	1.06	1.39	1.44	130	108	102	74

Section B	Difference in Means: Male Minus Female				Ratio of Means: $\left(\frac{\text{Male}}{\text{Female}}\right) \cdot 100$			
	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White	.34	.37	.54	.51	102.1	101.9	102.4	101.9
Negro	.41	.62	.79	.55	102.5	103.1	103.5	102.0
	White Minus Negro				$\left(\frac{\text{White}}{\text{Negro}}\right) \cdot 100$			
Male	−.25	−.59	−.66	−1.11	98.5	97.1	97.2	96.1
Female	−.18	−.34	−.41	−1.07	98.9	98.3	98.2	96.2

Section C	Quartile Values (cms.)											
	Birth			3 Months			6 Months			12 Months		
	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile
White Males	15.72	16.34	16.98	19.10	19.92	20.79	21.89	22.65	23.47	26.17	27.23	28.36
White Females	15.42	16.06	16.67	18.80	19.56	20.37	21.20	22.20	23.09	25.87	26.82	27.77
Negro Males	15.92	16.65	17.30	19.85	20.61	21.33	22.42	23.29	24.32	27.34	28.45	29.45
Negro Females	15.61	16.20	16.93	19.25	19.97	20.65	21.57	22.50	23.49	26.82	27.89	28.79

Table 5a. Means of the ratio $\left(\frac{\text{crown-rump length}}{\text{crown-sole length}} \cdot 100\right)$ by age and by race and sex.

Race and Sex	Mean				Standard Deviation				Number			
	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White Males	67.5	67.4	66.6	64.5	1.4	1.4	1.3	1.4	411	238	215	124
White Females	67.8	67.4	66.7	64.5	1.4	1.3	1.4	1.4	327	203	181	111
Negro Males	66.9	66.4	65.7	63.2	1.3	1.2	1.6	1.4	142	126	123	82
Negro Females	67.3	66.8	66.0	63.3	1.4	1.3	1.6	1.3	130	108	102	74

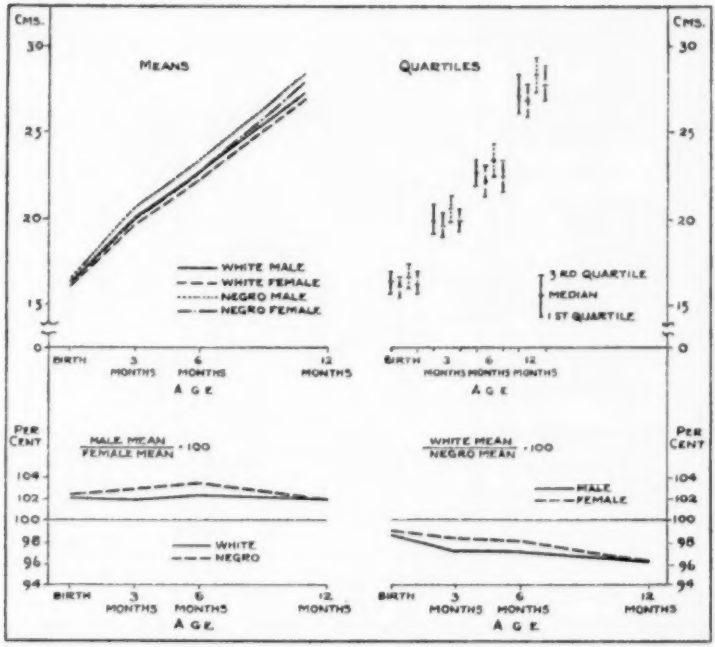

Fig. 5. Mean and quartile values of rump-sole length by age and by race and sex.

in Negro infants compared with the white babies is reflected in the means of the ratio $\frac{\text{(crown-rump length)}}{\text{(crown-sole length)}} \cdot 100$ at each age for each race-sex group (Table 5a). At each age, crown-rump length, on the average, constitutes a higher proportion of the total length among white infants than it does among Negroes, although the differences in the mean ratios are small. Among both races, the average proportion decreases during the first year of life from around 67.6 per cent for white infants and 67.0 per cent for Negroes at birth to 64.5 and 63.2 per cent for the two race groups at twelve months of age.

Hip Breadth (Table 6 and Figure 6). The means and quartile values of the distributions of this measurement fall into a pattern that differs from that of most of the other measure-

Table 6. Mean and quartile values of hip breadth by age and by race and sex.

Race and Sex	Mean (cms.)				Standard Deviation				Number			
Section A	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White Males	8.18	10.72	11.87	13.06	.52	.55	.61	.71	387	229	213	122
White Females	7.96	10.32	11.42	12.66	.48	.50	.64	.81	318	199	172	110
Negro Males	7.85	10.27	11.30	12.25	.55	.54	.68	.77	135	123	121	79
Negro Females	7.72	9.90	10.90	11.97	.49	.59	.71	.77	122	108	103	71

	Difference in Means				Ratio of Means			
Section B	Male Minus Female				$\left(\frac{\text{Male}}{\text{Female}}\right) \cdot 100$			
	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White	.22	.40	.45	.40	102.8	103.9	103.9	103.2
Negro	.13	.37	.40	.28	101.7	103.7	103.7	102.3
	White Minus Negro				$\left(\frac{\text{White}}{\text{Negro}}\right) \cdot 100$			
Male	.33	.45	.57	.81	104.2	104.4	105.0	106.6
Female	.24	.42	.52	.69	103.1	104.2	104.8	105.8

	Quartile Values (cms.)											
Section C	Birth			3 Months			6 Months			12 Months		
	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile
White Males	7.82	8.20	8.53	10.33	10.71	11.08	11.42	11.84	12.30	12.59	13.05	13.48
White Females	7.64	7.95	8.30	9.99	10.31	10.68	11.01	11.39	11.85	12.14	12.56	13.13
Negro Males	7.45	7.84	8.28	9.90	10.25	10.62	10.85	11.28	11.77	11.74	12.21	12.69
Negro Females	7.33	7.70	8.07	9.55	9.85	10.33	10.53	10.90	11.38	11.42	11.96	12.55

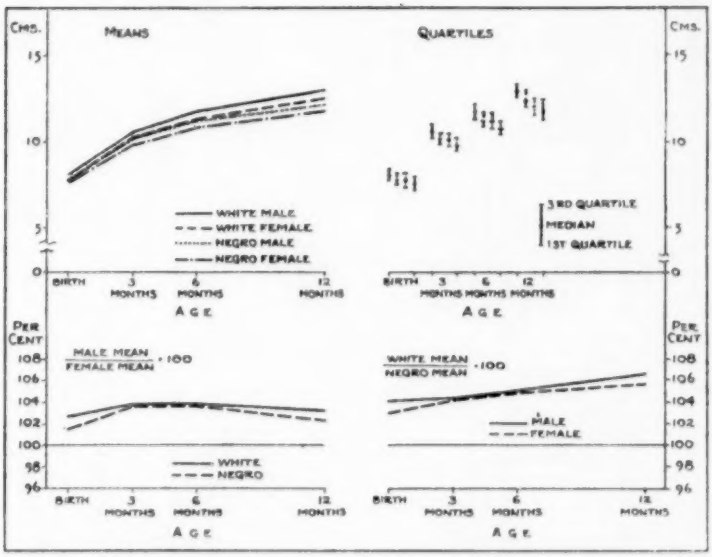

Fig. 6. Mean and quartile values of hip breadth by age and by race and sex.

ments. At each age both the means and quartiles fall in descending order of magnitude from the value for white males, followed by those for white females, Negro males, and Negro females. For example, at twelve months the means for hip breadth for these four groups are, respectively, 13.06 cms., 12.66 cms., 12.25 cms., and 11.97 cms. This pattern contrasts to that noted for most of the other measurements for which the values for males are usually greater than those for females regardless of race. The means for males, though always larger than those for females of the same race, never exceed the latter values by more than .5 cms. In relative terms those differences are between 2 and 4 per cent and are slightly greater than those found for most of the other dimensions. The percentage difference between the means for white and Negro babies of the same sex increases steadily during the year of observation from 3 and 4 per cent at birth to almost 7 per cent for males and almost 6 per cent for females at twelve months.

Head Circumference (Table 7 and Figure 7). In this popu-

Table 7. Mean and quartile values of head circumference by age and by race and sex.

Race and Sex	Mean (cms.)				Standard Deviation				Number			
Section A	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White Males	34.56	40.55	43.69	46.94	1.35	1.23	1.16	1.37	506	265	234	131
White Females	33.79	39.60	42.49	45.49	1.24	1.11	1.23	1.33	406	246	212	124
Negro Males	34.44	40.94	44.08	47.09	1.33	1.19	1.23	1.53	161	151	138	92
Negro Females	33.78	39.97	42.97	46.17	1.21	1.15	1.21	1.58	149	129	118	82

Section B	Difference in Means: Male Minus Female				Ratio of Means: $\left(\frac{\text{Male}}{\text{Female}}\right) \cdot 100$			
	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White	.77	.95	1.20	1.45	102.3	102.4	102.8	103.2
Negro	.66	.97	1.11	.92	102.0	102.4	102.6	102.0
	White Minus Negro				$\left(\frac{\text{White}}{\text{Negro}}\right) \cdot 100$			
Male	.12	−.39	−.39	−.15	100.3	99.0	99.1	99.7
Female	.01	−.37	−.48	−.68	100.0	99.1	98.9	98.5

Section C	Quartile Values (cms.)											
	Birth			3 Months			6 Months			12 Months		
	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile
White Males	33.69	34.58	35.50	39.72	40.56	41.41	42.84	43.66	44.47	45.95	46.93	47.86
White Females	33.10	33.87	34.62	38.95	39.56	40.28	41.62	42.46	43.32	44.59	45.43	46.28
Negro Males	33.57	34.52	35.42	40.09	41.03	41.74	43.20	44.12	44.92	46.20	47.23	48.00
Negro Females	33.08	33.74	34.63	39.18	39.99	40.74	42.12	43.07	43.74	45.03	46.19	46.98

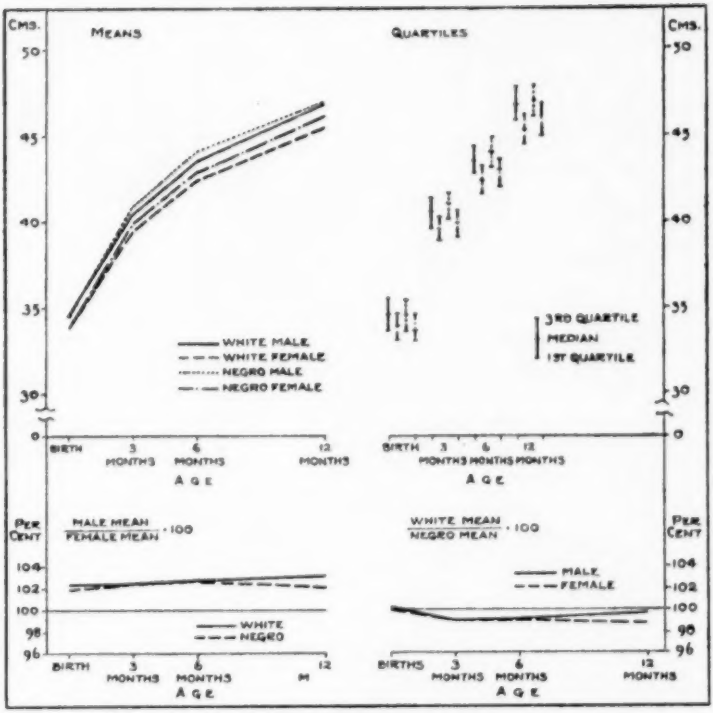

Fig. 7. Mean and quartile values of head circumference by age and by race and sex.

lation the average head circumference at birth is about 34.5 cms. for males and 33.8 cms. for females. At twelve months the largest mean is that for Negro males (47.09 cms.) and the smallest that for white females (45.49 cms.). The mean of head circumference for males is always larger than the corresponding mean for females by between 2 and 3 per cent. Except at birth, where no difference by race is found, the means for the Negro babies are larger than the means for white babies of the same sex, although the differences are relatively small, being less than 2 per cent of the means for Negroes. The quartile values also show this tendency toward a larger head circumference among Negroes at the three-month observation

Table 8. Mean and quartile values of calf circumference by age and by race and sex.

Race and Sex	Mean (cms.)				Standard Deviation				Number			
Section A	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White Males	11.51	16.19	18.66	20.26	.93	1.27	1.33	1.39	145	78	87	58
White Females	11.39	15.50	18.15	19.95	.99	1.06	1.31	1.58	115	64	65	40
Negro Males	11.13	15.95	18.27	19.72	1.04	1.07	1.28	1.36	71	64	64	37
Negro Females	11.28	15.61	17.85	19.37	1.03	1.27	1.55	1.59	69	56	54	38

	Difference in Means				Ratio of Means			
Section B	Male Minus Female				$\left(\frac{\text{Male}}{\text{Female}}\right) \cdot 100$			
	Birth	3 Months	6 Months	12 Months	Birth	3 Months	6 Months	12 Months
White	.12	.69	.51	.31	101.1	104.5	102.8	101.6
Negro	−.15	.34	.42	.35	98.7	102.2	102.4	101.8
	White Minus Negro				$\left(\frac{\text{White}}{\text{Negro}}\right) \cdot 100$			
Male	.38	.24	.39	.54	103.4	101.5	102.1	102.7
Female	.11	−.11	.30	.58	101.1	99.3	101.7	103.0

	Quartile Values (cms.)											
Section C	Birth			3 Months			6 Months			12 Months		
	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile
White Males	10.90	11.49	12.19	15.26	16.18	17.11	17.88	18.79	19.63	19.30	20.29	21.30
White Females	10.73	11.33	12.09	14.73	15.50	16.25	17.28	18.23	18.91	18.83	19.90	20.82
Negro Males	10.45	11.09	11.79	15.17	15.83	16.67	17.33	18.35	19.29	18.78	19.54	20.55
Negro Females	10.60	11.32	11.96	14.67	15.69	16.56	16.79	17.92	18.89	18.39	19.33	20.21

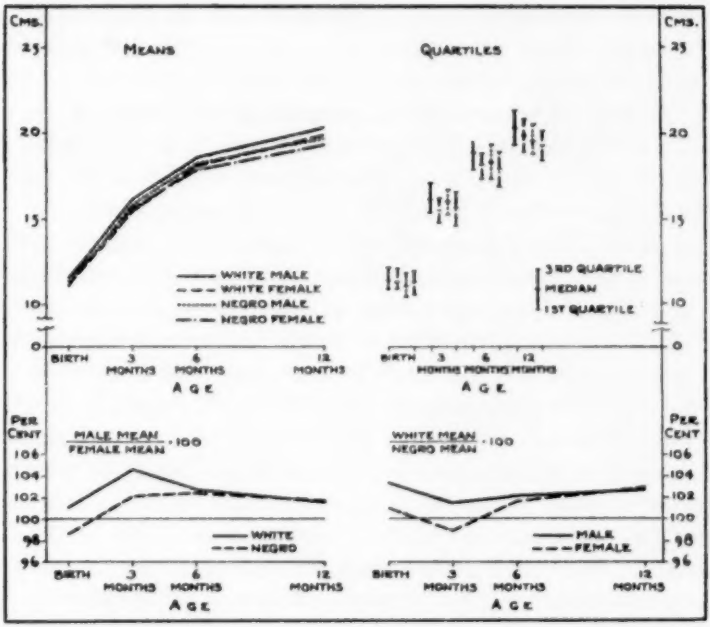

Fig. 8. Mean and quartile values of calf circumference by age and by race and sex.

and after. All three quartile measurements are larger for Negroes than the corresponding value for white babies at each age except birth. The quartile values also demonstrate the even larger differences in this measurement by sex.

Calf Circumference (Table 8 and Figure 8). The means and quartiles of this measurement present a more irregular picture than was found for the other measurements, possibly because they are based on a smaller number of observations. The average values for males are larger than those for females of the same race except for Negroes at birth. This difference is as great as 4.5 per cent for white infants at three months, but usually is about 2 per cent. The means for white babies are at most periods between 1 and 3 per cent greater than the corresponding value for Negroes. The quartile values also are in no consistent pattern. At twelve months they fall in descend-

ing order from white male, to white female, to Negro male, to Negro female, as was observed for hip breadth, but the number of cases from which they were calculated is small.

For each of these eight measurements, the mean values for the male babies are almost always greater than the means for females of the same race. The greatest relative difference in the means by sex is found for weight at three months of age and after. This differential is between 6 and 8 per cent. For most of the other measurements the relative differences are of the order of 2 to 4 per cent, and in most cases tend to be slightly lower at birth than at the subsequent observations.

Comparison of the means by race indicates that the white babies in this population tend to be larger than the Negroes of the same sex in weight, chest circumference, crown-rump length, hip breadth, and calf circumference. Negro babies have larger average values for rump-sole length, and head circumference, while no racial difference is found for crown-sole length. The most pronounced differences between the race groups are observed for rump-sole length and hip breadth.

The average per cent gain from birth to three, six, and twelve months of age is given for five of the measurements in Table 9. The largest relative increases are observed for weight. Between birth and three months of age the average per cent gain in weight for males is over 80 per cent and for females it is almost 75 per cent. During the first year of life the mean per cent increase is over 200 per cent, indicating that, on the average, these babies tripled their weight within this period. The mean per cent gain for males is about 10 per cent greater than that for females during each of these three intervals. In the periods, birth to three months and birth to six months, the average relative increases for the Negro babies are slightly above those for white infants of the same sex, but over the twelve-month interval, the larger means are found for the white population.

The average increase in chest circumference between birth and three months of age is above 27 per cent for males and 24

per cent for females and during the first year is between 45 and 52 per cent. The males have a mean per cent gain about 3 per cent above that for females during each period and there is almost no difference in the means by race, except over the one year period, when the means for white babies are about 2 per cent above those for Negroes.

The mean per cent gain in crown-sole length is slightly more than 20 per cent during the first three months of life and over 50 per cent by the end of the first twelve months. The means for males are a little larger than those for females, and, although the differences by race are small, there may be some tendency for the relative increase in crown-sole length to be larger in the Negro infants. The standard deviations of per cent gain in length are smaller than any of the others shown in Table 9, indicating that there is less variation among the infants in gain in this dimension.

The average increase in hip breadth during the first three months is between 29 and 32 per cent. During the first year the mean per cent gain ranges from 56 per cent to 61 per cent. The means for the male babies are larger than those for females of the same race, and the means for the white babies are always greater than those for Negroes of the same sex. During the twelve-month period, the average relative increases for both white groups are larger than those for the Negro infants.

The mean per cent gain in calf circumference in the first three months of life is between 36 and 46 per cent and in the first year between 73 and 86 per cent. The averages for males are consistently greater than those for females. The differences by race are inconsistent within the two sex groups.

Of the five measurements considered here, the greatest average relative gain during the first year of life is found for weight. Among the measurements of body dimensions, the largest mean per cent increases are found for calf circumference, followed by hip breadth, crown-sole length, and chest circumference. Relative growth for all these measurements is usually greater for males than for females, but differences

Race and Sex	Mean Per Cent Gain from Birth to:			Standard Deviation of Per Cent Gain from Birth to:			Number: Birth to:		
	3 Months	6 Months	12 Months	3 Months	6 Months	12 Months	3 Months	6 Months	12 Months
	WEIGHT								
White Males	80.4	141.8	215.0	19.9	30.2	41.1	265	238	134
White Females	72.0	129.4	204.2	18.9	29.5	43.8	247	212	122
Negro Males	83.7	142.4	212.3	22.4	34.4	48.9	151	141	92
Negro Females	74.4	130.9	201.6	22.3	32.1	44.1	130	120	84
	CHEST CIRCUMFERENCE								
White Males	27.3	38.2	51.4	6.2	6.7	7.6	241	215	121
White Females	24.1	35.6	47.3	6.0	6.7	7.7	207	174	100
Negro Males	27.4	38.5	48.9	7.2	8.6	8.7	131	122	80
Negro Females	24.5	35.0	45.2	6.8	7.9	9.0	113	103	72
	CROWN-SOLE LENGTH								
White Males	21.6	35.0	53.0	3.0	4.0	4.4	244	218	125
White Females	20.7	33.5	51.6	3.2	4.0	5.3	206	173	103
Negro Males	22.2	35.9	53.6	3.9	5.3	6.6	132	124	81
Negro Females	21.7	34.2	53.5	3.6	4.7	5.7	114	106	73
	HIP BREADTH								
White Males	32.1	46.3	61.0	8.1	10.6	10.6	191	175	98
White Females	30.0	44.2	60.0	7.8	10.6	11.4	167	137	80
Negro Males	31.5	45.2	57.7	8.0	10.2	9.9	106	98	61
Negro Females	28.7	42.0	55.8	7.6	10.8	11.2	94	87	58
	CALF CIRCUMFERENCE								
White Males	45.0	65.4	79.1	10.8	17.3	14.4	51	59	25
White Females	35.9	56.5	76.3	11.2	13.1	18.9	41	39	17
Negro Males	45.3	68.0	85.4	13.0	16.7	16.5	52	51	24
Negro Females	39.9	60.8	73.5	13.9	20.6	16.4	49	47	26

Table 9. Mean per cent gain in selected measurements between birth and three, six, and twelve months of age by race and sex.

among the means by race are less consistent than those by sex.

An estimate of the amount and direction of the association between the size of the measurements at each age is furnished by the coefficients of correlation between each pair of measurements (Table 10). Each coefficient is the weighted combination of the set of four coefficients, one for each race-sex group,

computed for each pair of measurements. Before they were combined, the four correlations were tested for homogeneity,[6] and the 15 of the 104 sets of coefficients found not to be homogeneous are given in Table 11, and their weighted combination shown in italics in Table 10. Each correlation coefficient is shown twice in Table 10, once under each of the two measurements being correlated. To avoid correlating a whole with its parts, the correlation between crown-sole length, and both crown-rump and rump-sole length, are not shown in the table.

At birth, the highest correlations are those between weight and each of the other measurements, except rump-sole length. All of these coefficients are above .60 and four of them exceed .70. Also above .60 are the coefficients of correlation between chest circumference and crown-sole length, crown-rump length, and calf circumference. The lowest correlations are those between rump-sole length and the other five body dimensions (.23 to .38). The coefficients of correlation among the other measurements are between .40 and .59.

The correlations among the measurements from the examination at three months are, in general, slightly smaller than the corresponding values at birth. The correlations between weight and chest circumference, crown-rump length and calf circumference are over .70 and those between weight and crown-sole length and hip breadth are above .60. The coefficients for rump-sole length and all other measurements are under .31. All the remaining coefficients are between .30 and .59.

[6] The procedure for testing homogeneity and combining the coefficients of the four race-sex groups was as follows:

$$\bar{z} = \frac{\Sigma(n_i - 3)z_i}{\Sigma(n_i - 3)}$$

$$\bar{r} = \tanh \bar{z}$$

$$\chi^2 = \Sigma(n_i - 3)z_i^2 - \frac{[\Sigma(n_i - 3)z_i]^2}{\Sigma(n_i - 3)}$$

where

z_i = Fisher transformation of the correlation coefficients, r_i, of the race-sex groups,

n_i = number of observations from which r_i was computed,

$\bar{r}$ = estimate of the combined r_i.

If with 3 degrees of freedom, one less than the number of correlations being tested, $P(\chi^2) < .05$ then the four coefficients were considered non-homogeneous. *Cf.* Weatherburn (3).

Measurement	Birth	Three Months	Six Months	Twelve Months	Birth	Three Months	Six Months	Twelve Months
	Weight				Chest Circumference			
Weight	—	—	—	—	*.76*	.74	.75	.75
Chest Circumference	*.76*	.74	.75	.75	—	—	—	—
Crown-Sole Length	.77	.65	.65	.68	*.62*	.52	.49	.49
Crown-Rump Length	.76	.71	.72	.75	.65	.56	.54	.56
Rump-Sole Length	.45	.31	.25	.29	.38	.25	.18	.23
Hip Breadth	*.64*	.67	.67	*.69*	*.56*	.57	.55	*.58*
Head Circumference	.64	.55	.50	.50	.54	.47	.42	.40
Calf Circumference	.74	.75	*.75*	.78	*.64*	*.48*	.51	*.53*
	Rump-Sole Length				Hip Breadth			
Weight	.45	.31	.25	.29	*.64*	.67	.67	*.69*
Chest Circumference	.38	.25	.18	.23	*.56*	.57	.55	*.58*
Crown-Sole Length	—	—	—	—	*.54*	.48	.48	*.52*
Crown-Rump Length	.27	.29	.21	.22	*.50*	.53	.52	*.58*
Rump-Sole Length	—	—	—	—	.31	.20	.19	.21
Hip Breadth	.31	.20	.19	.21	—	—	—	—
Head Circumference	.32	.25	.17	.15	.44	.33	.29	*.28*
Calf Circumference	.23	.14	.12	.00	.57	*.43*	.46	.46

Number

	Birth							
	Wt.	Ch.	C-S	C-R	R-S	Hip	Head	Calf
Weight		1,223	1,227	1,010	1,010	962	1,222	400
Chest Circumference	784		1,212	1,009	1,009	962	1,219	400
Crown-Sole Length	784	790		—	—	960	1,209	398
Crown-Rump Length	667	673	—		1,010	957	1,009	397
Rump-Sole Length	667	674	—	674		957	1,009	397
Hip Breadth	651	658	658	653	653		962	378
Head Circumference	783	790	789	674	674	658		400
Calf Circumference	257	261	261	259	259	261	261	
	3 Months							

Note: Coefficients in italics are based on coefficients by race and sex which are not homogeneous.

Table 10. Correlations between measurements by age.

The coefficients at six months and twelve months of age are about equal to or slightly smaller than those for the three month examination. As at the two earlier periods, the highest correlations are those involving weight, all but two of which

Birth	Three Months	Six Months	Twelve Months	Birth	Three Months	Six Months	Twelve Months
crown-sole length				crown-rump length			
.77	.65	.65	.68	.76	.71	.72	.75
.62	.52	.49	.49	.65	.56	.54	.56
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	.27	.29	.21	.22
.54	.48	.48	.52	.50	.53	.52	.58
.57	.45	.41	.40	.59	.51	.45	.46
.54	.36	.38	.35	.54	.40	.37	.51
head circumference				calf circumference			
.64	.56	.50	.50	.74	.75	.75	.78
.54	.47	.42	.40	.64	.48	.51	.53
.57	.45	.41	.40	.54	.36	.38	.35
.59	.51	.45	.46	.54	.40	.37	.51
.32	.25	.17	.15	.23	.14	.12	.00
.44	.33	.29	.28	.57	.43	.46	.46
—	—	—	—	.51	.38	.24	.34
.51	.38	.24	.34	—	—	—	—

Number

6 months							
Wt.	Ch.	C-S	C-R	R-S	Hip	Head	Calf
	691	699	617	617	605	698	268
418		695	616	616	605	695	265
422	423		—	—	609	702	270
385	386	—		621	605	621	268
385	386	—	391		605	621	268
376	377	382	378	378		609	264
423	424	428	391	391	382		270
171	171	173	172	173	172	173	
12 Months							

at each age are above .60. Coefficients under .25 are observed for rump-sole length with the other dimensions and for head circumference with hip breadth and, at six months, with calf circumference.

At all four ages, each of the seven body dimensions is more highly correlated with weight than with any of the other dimen-

sions. Weight is most highly correlated (above .70) with chest circumference, crown-rump length, and calf circumference, and the measurement with the least association with weight is rump-sole length (.29 to .45). The minimum correlations for each of the other measurements are also with rump-sole length.

The correlations between the dimensions, chest circumference, crown-sole length, crown-rump length, and calf circumference are all at approximately the same level. Hip breadth could also be included in this group, but it should be noted that most of the coefficients involving this measurement at

Table 11. Correlations between measurements by race and sex which are not homogeneous by race and sex.

Measurements	Age	Correlation Coefficient				Number			
		White Male	White Female	Negro Male	Negro Female	White Male	White Female	Negro Male	Negro Female
Weight and Chest Circumference	Birth	.77	.71	.86	.75	508	406	161	148
Chest Circumference and Crown-Sole Length	Birth	.61	.56	.75	.60	504	400	161	147
Hip Breadth and Weight	Birth	.61	.59	.75	.70	387	318	135	122
Hip Breadth and Chest Circumference	Birth	.55	.50	.67	.64	387	318	135	122
Hip Breadth and Crown-Sole Length	Birth	.50	.50	.68	.57	385	318	135	122
Hip Breadth and Crown-Rump Length	Birth	.44	.47	.64	.60	384	316	135	122
Chest Circumference and Calf Circumference	3 Months	.47	.48	.28	.68	78	63	64	56
Hip Breadth and Calf Circumference	3 Months	.46	.41	.19	.62	78	63	64	56
Weight and Calf Circumference	6 Months	.68	.78	.66	.87	85	65	64	54
Chest Circumference and Calf Circumference	12 Months	.35	.67	.72	.37	58	38	37	38
Hip Breadth and Weight	12 Months	.57	.69	.70	.81	121	106	78	71
Hip Breadth and Chest Circumference	12 Months	.46	.63	.52	.74	121	107	78	71
Hip Breadth and Crown-Sole Length	12 Months	.49	.40	.55	.70	122	110	79	71
Hip Breadth and Crown-Rump Length	12 Months	.52	.44	.68	.74	120	109	78	71
Hip Breadth and Head Circumference	12 Months	.16	.24	.53	.24	122	110	79	71

birth and twelve months are derived from non-homogeneous sets of coefficients. At birth the coefficients of correlation between these measurements are between .54 and .65 and at the later ages, are, with a few exceptions, between .45 and .55. The correlations between head circumference and these measurements are slightly smaller.

The correlation coefficients for each race-sex group for the fifteen sets of coefficients which were found to be non-homogeneous are given in Table 11. Ten of the fifteen involve the measurement of hip breadth. At birth, in the four sets of correlations with hip breadth the coefficients for Negroes are consistently larger than those for white infants, and, thus, the combined coefficient understates the correlation among Negroes and slightly overstates it for the white groups. At twelve months the same four sets of correlations with hip breadth are in a similar pattern, except that in addition, hip breadth is more highly correlated with weight and chest circumference among females than among males. The variation by race and sex for most of the other non-homogeneous sets of correlations is erratic.

The correlation between the size of each measurement at one examination with the size of the same measurement at a later period (Table 12) affords an estimate of the accuracy of the prediction of size at one period from an earlier observation and also indicates the consistency of growth.

The coefficients for each of the four race-sex groups have been combined to give the coefficients shown here and all such sets are homogeneous. The observations from each examination are most highly correlated with the observations at an adjacent period, as follows: birth with three months, three months with six months, six months with both three months and twelve months, and twelve months with six months. Most measurements at three, six, and twelve months show the least correlation with the observations at birth, while the birth measurements are generally most poorly correlated with the observations at twelve months.

Table 12. Coefficients of correlation between measurements at each age.

Age	Three Months	Six Months	Twelve Months	Three Months	Six Months	Twelve Months	Three Months	Six Months	Twelve Months	Three Months	Six Months	Twelve Months
	CORRELATION COEFFICIENT											
	Weight			Chest Circumference			Crown-Sole Length			Crown-Rump Length		
Birth	.56	.43	.38	.46	.40	.38	.77	.66	.59	.68	.58	.48
3 Months		.81	.68		.74	.57		.82	.76		.78	.69
6 Months			.86			.74			.83			.80
	Rump-Sole Length			Hip Breadth			Head Circumference			Calf Circumference		
Birth	.63	.51	.48	.43	.33	.33	.66	.56	.51	.40	.22	.29
3 Months		.67	.58		.73	.64		.82	.74		.70	.54
6 Months			.65			.79			.80			.73
	NUMBER											
	Weight			Chest Circumference			Crown-Sole Length			Crown-Rump Length		
Birth	794	711	432	693	614	373	697	620	382	587	531	315
3 Months		666	424		651	418		658	422		559	345
6 Months			428			413			417			358
	Rump-Sole Length			Hip Breadth			Head Circumference			Calf Circumference		
Birth	587	531	315	557	493	297	691	617	377	193	196	92
3 Months		559	345		542	335		658	423		209	118
6 Months			357			347			418			133

The highest correlations between the birth measurements and those at the later periods are found for crown-sole length, for which the birth and three-month correlation is .77 and the birth and six-month and birth and twelve-months values are .66 and .59, respectively. Slightly lower coefficients for these same periods are observed for the other two length segments and head circumference. The lowest of this set of correlations are those for calf circumference (.40, .22, and .29). This suggests that potential length and head circumference are established to a greater extent at birth than are the other dimensions and that possibly they are less affected by external influences during infancy. Consistently higher values are seen for the correlations between the observations at three and six months and six and twelve months. These coefficients are near .80 or above for weight, crown-sole length, crown-rump length, and head circumference, and the lowest of this set, those for rump-sole length, are .65. These higher correlations, compared with those with the birth observations, indicate that the measurements at three and six months are a better index of later size than are those made at birth.

Increments of Growth between Examinations

The mean increments for each measurement in each interval between examinations are presented in Table 13 and Figure 9 and the quartile values of the distributions of the increments in Table 14 and Figure 10. In addition, the means and quartile values for the periods, birth to six months and birth to twelve months, are shown in the two tables. The means and quartiles are based on the number of babies measured at both the beginning and end of each interval.

Weight. The mean increase in weight during the first three month period was slightly over 6.0 lbs. for males and about 5.2 lbs. for females. In the next three months the average weight gain varied between 4.0 lbs. for Negro females and 4.6 lbs. for white males. The increase in weight in this interval tended to be larger both for males than for females and for

Period	Mean Gain				Standard Deviation				Number			
	White Male	White Female	Negro Male	Negro Female	White Male	White Female	Negro Male	Negro Female	White Male	White Female	Negro Male	Negro Female
	WEIGHT (lbs.)											
Birth to 3 Months	6.01	5.19	6.11	5.24	1.24	1.10	1.22	1.41	264	248	151	130
3 Months to 6 Months	4.61	4.24	4.24	4.01	1.10	1.14	1.28	1.10	212	204	134	116
6 Months to 12 Months	5.31	5.12	5.34	5.11	1.50	1.37	1.44	1.28	132	120	91	84
Birth to 6 Months	10.56	9.37	10.34	9.23	1.75	1.73	2.01	1.98	238	212	141	120
Birth to 12 Months	15.96	14.47	15.36	14.25	2.46	2.49	2.67	2.64	134	122	92	84
	CHEST CIRCUMFERENCE (cms.)											
Birth to 3 Months	8.74	7.71	8.71	7.74	1.74	1.70	1.96	1.87	241	208	131	113
3 Months to 6 Months	3.76	3.68	3.52	3.49	1.32	1.20	1.33	1.25	207	202	131	111
6 Months to 12 Months	3.83	3.62	3.42	3.30	1.56	1.44	1.37	1.36	126	119	87	81
Birth to 6 Months	12.37	11.42	12.18	11.15	1.75	1.88	2.25	2.13	215	174	122	103
Birth to 12 Months	16.49	15.05	15.51	14.43	2.08	2.15	2.18	2.47	121	100	80	72
	CROWN-SOLE LENGTH (cms.)											
Birth to 3 Months	10.80	10.30	11.08	10.73	1.31	1.43	1.55	1.56	243	207	132	114
3 Months to 6 Months	6.89	6.42	6.89	6.28	1.34	1.32	1.29	1.34	209	203	132	114
6 Months to 12 Months	9.03	8.89	9.12	9.59	1.47	1.50	1.67	1.36	127	122	87	81
Birth to 6 Months	17.61	16.67	17.91	16.84	1.69	1.74	2.19	1.94	217	173	124	106
Birth to 12 Months	26.52	25.36	26.66	26.16	1.92	2.26	2.52	2.44	124	103	81	73
	CROWN-RUMP LENGTH (cms.)											
Birth to 3 Months	7.22	6.82	7.17	6.87	1.13	1.09	.97	1.11	205	172	111	99
3 Months to 6 Months	4.21	3.95	4.09	3.63	.96	1.02	1.03	1.06	188	164	112	95
6 Months to 12 Months	4.26	4.08	3.89	4.28	1.00	1.18	1.25	1.19	116	100	72	68
Birth to 6 Months	11.24	10.77	11.26	10.38	1.36	1.33	1.45	1.55	190	146	104	91
Birth to 12 Months	15.57	14.79	15.04	14.52	1.45	1.75	1.60	1.82	105	84	65	61
	RUMP-SOLE LENGTH (cms.)											
Birth to 3 Months	3.69	3.52	3.96	3.82	1.03	.91	1.00	.91	205	172	111	99
3 Months to 6 Months	2.76	2.62	2.95	2.59	1.02	1.07	1.13	1.11	188	164	112	95
6 Months to 12 Months	4.71	4.76	4.97	5.49	1.25	1.34	1.18	1.14	116	100	72	68
Birth to 6 Months	6.44	6.03	6.79	6.40	1.17	1.12	1.48	1.31	190	146	104	91
Birth to 12 Months	10.98	10.58	11.72	11.73	1.34	1.24	1.49	1.33	105	84	65	61
	HIP BREADTH (cms.)											
Birth to 3 Months	2.61	2.38	2.49	2.24	1.07	1.03	1.01	1.08	190	167	106	94
3 Months to 6 Months	1.18	1.15	1.12	1.04	.41	.41	.46	.46	180	157	110	95
6 Months to 12 Months	1.18	1.23	1.05	1.25	.43	.48	.44	.44	113	97	70	67
Birth to 6 Months	3.71	3.49	3.55	3.25	.63	.66	.66	.73	172	136	98	87
Birth to 12 Months	4.94	4.73	4.49	4.26	.70	.78	.63	.74	98	80	61	58
	HEAD CIRCUMFERENCE (cms.)											
Birth to 3 Months	6.20	5.83	6.48	6.28	.97	.95	1.04	1.06	240	208	131	113
3 Months to 6 Months	3.13	2.92	3.25	3.09	.63	.62	.64	.69	209	203	132	114
6 Months to 12 Months	3.23	3.14	3.07	3.29	.79	.74	.72	1.00	127	122	88	81
Birth to 6 Months	9.30	8.59	9.81	9.40	1.08	1.12	1.17	1.23	215	174	123	105
Birth to 12 Months	12.54	11.74	12.85	12.47	1.30	1.19	1.27	1.60	122	103	81	72
	CALF CIRCUMFERENCE (cms.)											
Birth to 3 Months	5.08	4.08	5.00	4.45	1.08	1.14	1.26	1.34	51	41	52	49
3 Months to 6 Months	2.37	2.59	2.37	2.18	1.01	.85	1.04	.84	58	48	55	48
6 Months to 12 Months	1.75	2.11	1.86	2.04	.88	1.24	.80	.99	42	30	30	31
Birth to 6 Months	7.35	6.49	7.37	6.65	1.53	1.29	1.42	1.82	59	39	51	47
Birth to 12 Months	8.90	8.56	9.17	8.19	1.36	1.92	1.37	1.46	25	17	24	26

Table 13. Mean gain in each measurement between examinations, by race and sex.

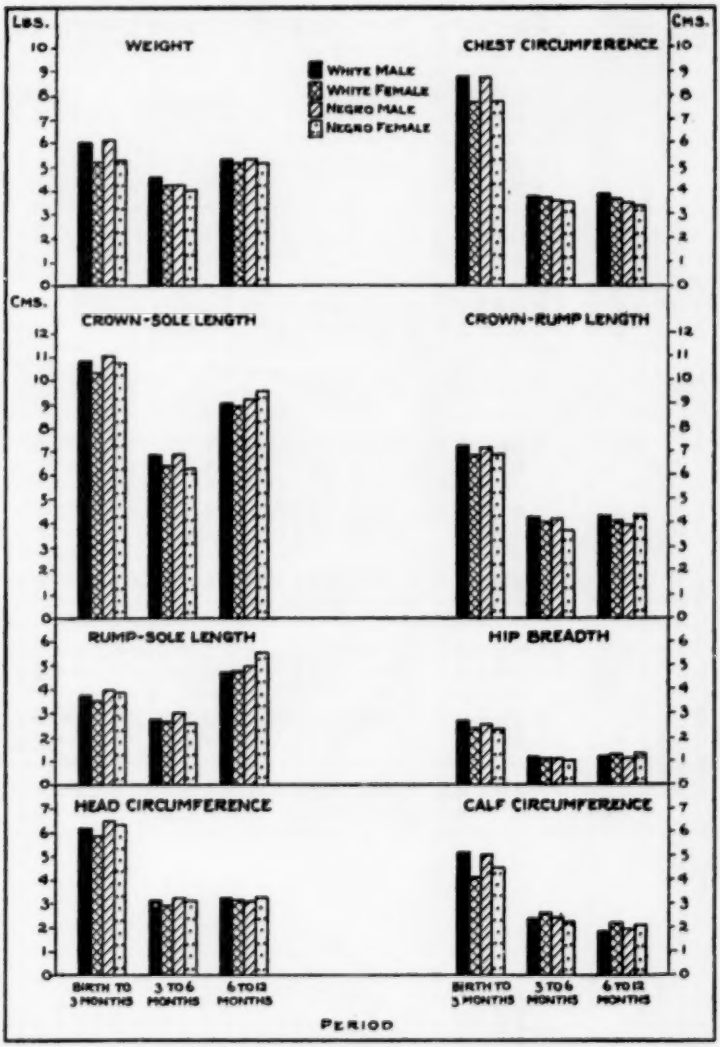

Fig. 9. Mean gain in each measurement between examinations, by race and sex.

white babies than for Negro infants. In the final six month period the means were 5.3 lbs. for males and 5.1 lbs for females.

Table 14. Quartile values of gain in each measurement between examinations, by race and sex.

Period	White Male			White Female			Negro Male			Negro Female		
	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile	1st Quartile	Median	3rd Quartile
	WEIGHT (lbs.)											
Birth to 3 Months	5.20	5.95	6.81	4.45	5.17	5.90	5.26	6.15	6.91	4.12	5.19	6.22
3 Months to 6 Months	3.78	4.55	5.41	3.41	4.14	4.92	3.35	4.15	4.88	3.24	3.89	4.73
6 Months to 12 Months	4.29	5.28	6.17	4.23	4.87	5.89	4.35	5.26	6.30	4.16	5.00	5.91
Birth to 6 Months	9.23	10.43	11.72	8.18	9.23	10.32	9.06	10.40	11.53	7.67	9.14	10.67
Birth to 12 Months	14.09	16.08	17.58	12.67	13.92	16.26	13.60	15.18	16.69	12.00	13.88	16.23
	CHEST CIRCUMFERENCE (cms.)											
Birth to 3 Months	7.44	8.69	9.93	6.48	7.73	8.95	7.37	8.67	10.07	6.41	7.63	8.99
3 Months to 6 Months	2.78	3.70	4.65	2.82	3.68	4.54	2.55	3.43	4.49	2.55	3.44	4.34
6 Months to 12 Months	2.58	3.73	4.98	2.51	3.62	4.62	2.43	3.41	4.38	2.33	3.24	4.21
Birth to 6 Months	11.08	12.45	13.66	10.06	11.50	12.66	10.78	11.93	13.85	9.65	11.19	12.75
Birth to 12 Months	15.09	16.53	17.91	13.50	15.10	16.50	13.73	15.62	17.00	13.00	14.50	15.91
	CROWN-SOLE LENGTH (cms.)											
Birth to 3 Months	9.95	10.81	11.73	9.35	10.28	11.15	10.21	11.12	11.78	9.79	10.69	11.73
3 Months to 6 Months	5.86	6.91	7.75	5.49	6.35	7.25	5.93	6.79	7.81	5.41	6.36	7.08
6 Months to 12 Months	8.03	9.10	10.01	7.79	8.89	9.83	7.98	9.07	10.16	8.73	9.66	10.56
Birth to 6 Months	16.44	17.54	18.68	15.45	16.57	17.82	16.35	17.76	19.24	15.54	16.95	17.88
Birth to 12 Months	25.16	26.60	27.84	23.75	25.18	26.89	24.98	26.50	28.11	24.45	26.26	27.61
	CROWN-RUMP LENGTH (cms.)											
Birth to 3 Months	6.41	7.22	7.92	6.09	6.77	7.60	6.49	7.24	7.77	6.02	6.82	7.69
3 Months to 6 Months	3.49	4.19	4.82	3.26	3.98	4.68	3.33	3.96	4.79	2.99	3.60	4.34
6 Months to 12 Months	3.51	4.27	4.93	3.33	4.24	4.89	3.04	3.83	4.70	3.36	4.08	5.29
Birth to 6 Months	10.30	11.10	12.13	9.83	10.66	11.66	10.26	11.13	12.28	9.43	10.43	11.31
Birth to 12 Months	14.55	15.56	16.55	13.46	14.82	16.07	13.80	14.96	16.08	13.43	14.59	15.67

	RUMP-SOLE LENGTH (cms.)											
Birth to 3 Months	3.03	3.65	4.41	2.80	3.49	4.19	3.28	3.90	4.65	3.19	3.74	4.47
3 Months to 6 Months	2.07	2.68	3.46	1.83	2.56	3.36	2.10	2.82	3.72	1.75	2.62	3.47
6 Months to 12 Months	3.91	4.71	5.60	3.75	4.76	5.68	4.11	5.04	5.79	4.61	5.35	6.22
Birth to 6 Months	5.57	6.35	7.16	5.23	6.08	6.78	6.00	6.79	7.76	5.51	6.42	7.24
Birth to 12 Months	10.05	11.05	11.87	9.69	10.67	11.50	10.92	11.78	12.69	10.79	11.74	12.72
	HIP BREADTH (cms.)											
Birth to 3 Months	2.23	2.60	2.93	2.05	2.37	2.74	2.12	2.47	2.84	1.83	2.27	2.68
3 Months to 6 Months	.86	1.18	1.45	.84	1.16	1.42	.76	1.10	1.44	.70	.97	1.31
6 Months to 12 Months	.87	1.18	1.44	.89	1.23	1.56	.71	.97	1.32	.90	1.21	1.49
Birth to 6 Months	3.28	3.72	4.12	3.04	3.40	3.92	3.09	3.48	3.94	2.81	3.26	3.71
Birth to 12 Months	4.44	4.89	5.51	4.21	4.67	5.15	4.05	4.40	4.99	3.71	4.28	4.84
	HEAD CIRCUMFERENCE (cms.)											
Birth to 3 Months	5.50	6.19	6.78	5.18	5.75	6.47	5.78	6.46	7.08	5.52	6.19	6.82
3 Months to 6 Months	2.58	3.16	3.64	2.40	2.89	3.46	2.77	3.31	3.73	2.55	3.16	3.62
6 Months to 12 Months	2.61	3.24	3.77	2.56	3.16	3.64	2.53	3.15	3.63	2.66	3.29	3.81
Birth to 6 Months	8.50	9.31	9.99	7.90	8.55	9.30	8.99	9.78	10.62	8.48	9.32	10.18
Birth to 12 Months	11.58	12.47	13.44	10.99	11.67	12.55	11.80	12.92	13.75	11.40	12.43	13.38
	CALF CIRCUMFERENCE (cms).											
Birth to 3 Months	4.34	5.04	5.78	3.51	3.90	4.90	4.25	4.86	5.86	3.51	4.31	5.40
3 Months to 6 Months	1.61	2.41	3.08	2.00	2.68	3.17	1.68	2.20	3.02	1.45	2.23	2.75
6 Months to 12 Months	1.14	1.72	2.34	1.42	1.85	2.81	1.29	1.81	2.38	1.20	1.85	2.91
Birth to 6 Months	6.29	7.38	8.35	5.65	6.55	7.53	6.29	7.47	8.52	5.13	6.58	8.13
Birth to 12 Months	8.04	8.93	9.96	7.25	8.13	9.75	8.00	9.20	10.33	7.17	7.89	9.17

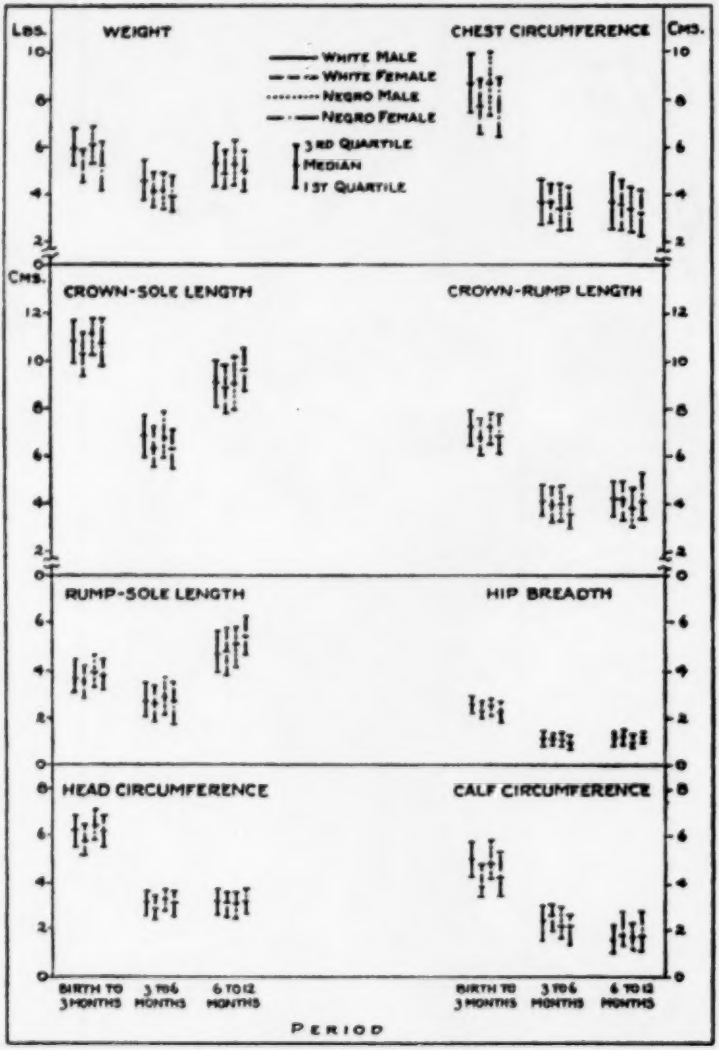

Fig. 10. Quartile values of gain in each measurement between examinations, by race and sex.

Chest Circumference. The average growth in chest circumference from birth to three months of age was greater for males

than for females. The means for both groups of male infants were about 8.7 cms. and those for the female babies about 1 cm. less. The difference by sex in the quartile values was such that the third quartiles for females barely exceeded the median values for males. In the next two intervals differences in the means by race and sex were small, but the mean values for males were slightly greater than those for females and those for white infants greater than those for Negroes. Between three and six months the mean increase varied between 3.49 cms. and 3.76 cms. and during the final six month period between 3.30 cms. and 3.83 cms.

Crown-Sole Length. The largest average gain in crown-sole length between birth and three months of age was found for Negro males (11.08 cms.) with that for the white male babies being slightly smaller (10.80 cms.). Among females the mean for Negroes (10.73 cms.) also exceeded that for white babies (10.30 cms.) during this period. Between three and six months of age the mean increase in crown-sole length was 6.9 cms. for both male groups and 0.5 to 0.6 cms. smaller for the two female groups. This difference by sex was also reflected in the quartile values. During the final period the mean for Negro females was 9.59 cms. while the values for the other three groups fell between 8.89 cms. and 9.12 cms.

Crown-Rump Length. The mean increase in this measurement between the birth and three months examinations was near 7.2 cms. for males and 6.85 cms. for females. During the next interval the means for the male groups were between 4.21 cms. and 4.09 cms. while the mean was 3.95 cms. for white females and 3.63 cms. for Negro females. From six to twelve months the largest average growth in crown-rump length was found for white males (4.26 cms.) and Negro females (4.28 cms.) and the smallest for Negro males (3.89 cms.).

Rump-Sole Length. In the initial period the mean increase in rump-sole length was greater among both groups of Negro infants than among the white population. The mean for Negro males was 3.96 cms. and for Negro females 3.82 cms. while

the corresponding values for white infants were 3.69 cms. and 3.52 cms. During the following period the largest average gain was among Negro males (2.95 cms.) and the smallest among Negro females (2.59 cms.). Between six and twelve months of age the largest mean increase was that for Negro female (5.49 cms.) with the means for the other race-sex groups ranging between 4.71 cms. for white males to 4.97 cms. for Negro males.

Hip Breadth. Although the differences among the means for growth in this dimension during the initial three month period were small there was a discernible pattern of larger increases among males and among white infants. This may also be seen in the quartile values. The mean for white males was 2.61 cms. and for Negro males 2.49 cms. and for females the corresponding values were 2.38 cms. and 2.24 cms. In the next interval there was almost no difference among the four values, all falling between 1.04 cms. and 1.18 cms. In the last interval the range of the means was from 1.05 cms. to 1.23 cms., but with some suggestion in the means and quartile values of slightly greater growth in this measurement among females than among males during this time.

Head Circumference. The average increase in this measurement during the first period was larger for Negroes and for males. The values for Negro males and females respectively, were 6.48 cms. and 6.28 cms., while for white babies the corresponding means were 6.20 cms. and 5.83 cms. In the next interval the same pattern may be observed, but the differences were smaller. The means ranged from 2.92 cms. for white females to 3.25 cms. for Negro males. In the last period all four means were between 3.07 cms. and 3.29 cms.

Calf Circumference. From birth to three months of age the mean gain in calf circumference was about 5.00 cms. for both groups of male infants while the mean for white females was about 1.0 cms. smaller and that for Negro females about 0.6 cms. less. During the three to six month interval the largest mean was observed for white females (2.59 cms.) and the

smallest for Negro females (2.18 cms.). From six to twelve months of age the mean gains were larger for females (2.11 cms. and 2.04 cms.) than for males (1.75 cms. and 1.89 cms.).

During the first three months after birth the male infants tended to have a greater absolute growth in all measurement than did females of the same race, but this difference was most marked for weight, chest circumference, and calf circumference. Racial differences in growth may be noted in crown-sole length, rump-sole length, and head circumference, for which the gain in Negro babies tended to be greater than that for white infants of the same sex, and in hip breadth for which the gain for white infants seemed to be larger.

In the next two periods the differences by race and sex were less consistent. Within each racial group in the interval from three to six months the average growth among males appears to be greater than that among females for weight, crown-sole and crown-rump length, and possibly head circumference. The differences by race during this period were small and generally irregular, although the average weight gain in white infants was larger than that for Negroes of the same sex.

In the six to twelve month interval the mean increase in weight and chest circumference was slightly larger in male than in female infants of the same race, while the mean gain in calf circumference was larger among females. During this time white infants had a greater average growth in chest circumference than did Negro babies and a smaller mean growth in rump-sole length.

Growth in these measurements during the intervals birth to six months and birth to twelve months was in much the same pattern with respect to age and sex differences as was growth during the birth to three month period. The average increase in each measurement for both groups of male infants during these two periods was almost always greater than the mean for either of the female groups. Exceptions to this were rump-sole length for the twelve month period for which the mean for Negro females exceeded that for white males and

Period	Mean Per Cent Gain				Standard Deviation				Number			
	White Male	White Female	Negro Male	Negro Female	White Male	White Female	Negro Male	Negro Female	White Male	White Female	Negro Male	Negro Female
	WEIGHT											
Birth to 3 Months	80.4	72.0	83.7	74.4	19.9	18.9	22.4	22.3	265	247	151	130
3 Months to 6 Months	33.6	33.8	31.3	32.4	8.3	8.5	8.9	8.8	212	204	134	116
6 Months to 12 Months	29.5	30.1	30.4	31.1	8.9	8.3	8.4	7.2	133	120	91	84
	CHEST CIRCUMFERENCE											
Birth to 3 Months	27.3	24.1	27.4	24.5	6.2	6.0	7.2	6.8	241	207	131	113
3 Months to 6 Months	9.1	9.1	8.6	8.8	3.4	3.1	3.4	3.1	207	202	131	111
6 Months to 12 Months	8.6	8.3	7.5	7.8	3.6	3.5	3.0	3.2	126	119	87	81
	CROWN-SOLE LENGTH											
Birth to 3 Months	21.6	20.7	22.2	21.7	3.0	3.2	3.9	3.6	244	206	132	114
3 Months to 6 Months	11.2	10.7	11.3	10.3	2.3	2.3	2.2	2.4	209	203	132	114
6 Months to 12 Months	13.3	13.3	13.3	14.5	2.2	2.4	2.5	2.2	127	122	87	81
	HIP BREADTH											
Birth to 3 Months	32.1	30.0	31.5	28.7	8.1	7.8	8.0	7.6	191	167	106	94
3 Months to 6 Months	10.6	10.7	10.4	10.0	3.9	3.9	4.2	4.4	180	157	110	95
6 Months to 12 Months	9.7	10.6	9.3	11.0	3.5	3.9	4.1	4.3	113	97	70	67
	CALF CIRCUMFERENCE											
Birth to 3 Months	45.0	35.9	45.3	39.9	10.8	11.2	13.0	13.9	51	41	52	49
3 Months to 6 Months	14.5	16.3	14.7	13.7	6.6	5.6	7.0	5.5	58	48	55	48
6 Months to 12 Months	9.6	11.9	10.2	11.5	5.5	7.2	4.7	5.9	42	30	30	31

Table 15. Mean per cent gain between examinations for selected measurements, by race and sex.

equaled that for Negro males and hip breadth during the same interval for which the mean for white females equaled that for Negro males. During these two periods the average gain was greater for white than for Negro babies of the same sex for chest circumference and hip breadth, and, over the twelve month interval, for crown-rump length. The means for Negro infants were the larger for rump-sole length and head circumference.

The mean percentage increase for five of the measurements during the intervals birth to three, three to six, and six to

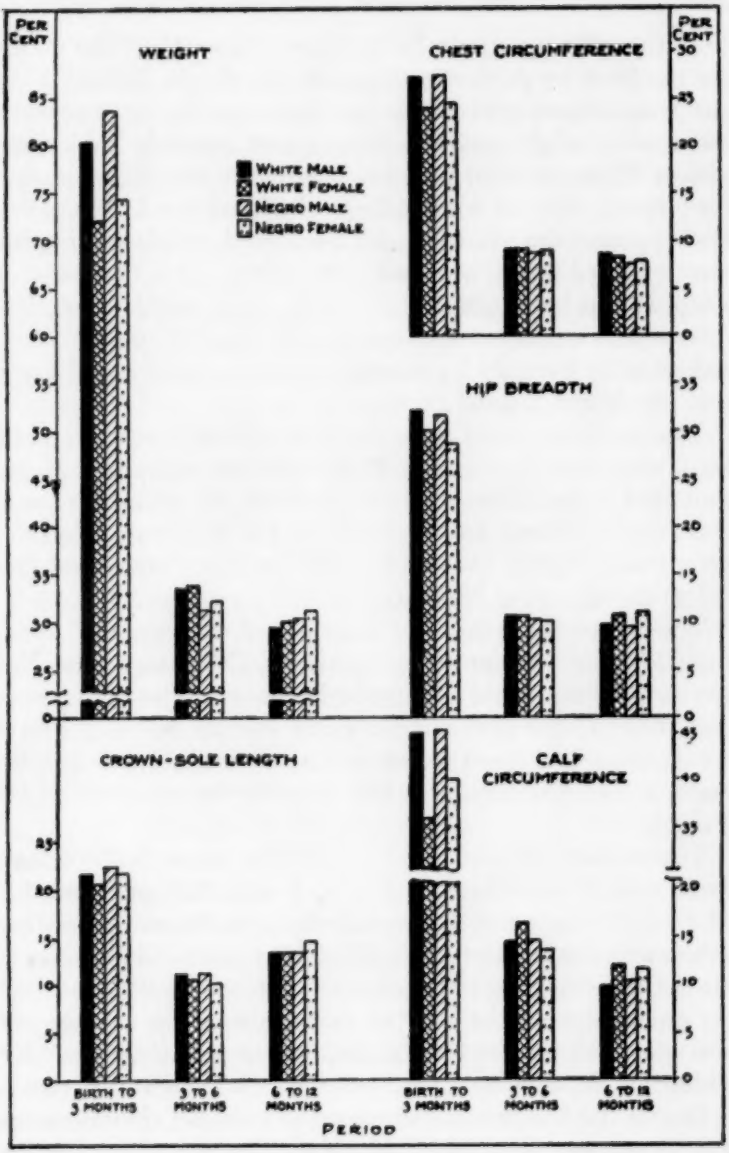

Fig. 11. Mean per cent gain between examinations for selected measurements, by race and sex.

twelve months is given in Table 15 and Figure 11. (The means for the birth to three month period are also in Table 9.) In the period from birth to three months of age, the mean per cent increase in weight was over 80 per cent for male babies and almost 75 per cent for females. The mean was slightly larger for Negroes than for white infants of the same sex. In the following period the average gains were much smaller falling between 31 and 34 per cent, with the values for both groups of white infants being a little larger than those for Negroes. The means were somewhat lower during the final six month interval, ranging from 29.5 per cent for white males to 31.1 per cent for Negro females.

The mean per cent gain in chest circumference between birth and three months was 27 per cent for males and 24 per cent for females. During the next interval, the average increase was near 9 per cent for all groups, and in the final period the means were slightly above 8 per cent for white babies and just below this figure for Negroes.

The means for crown-sole length in the first period range from 20.7 per cent for white females to 22.2 per cent for Negro males. From three to six months the mean per cent gain is just above 11 per cent for males and slightly below this level for females. The mean values in the last period for Negro females is 14.5 per cent, and 13.3 per cent for the other three groups.

The average increase in hip breadth between the birth and three month examinations was 32.1 and 31.5 per cent for white and Negro males, respectively, and the corresponding values for females were 30.0 and 28.7 per cent. All four means for the three to six month interval fell between 10.0 and 10.7 per cent. Between the last two examinations, the average per cent gain was greater for females, 10.6 and 11.0 per cent for white and Negro infants, than for males (9.7 and 9.3 per cent).

During the first interval the mean gain in calf circumference was 45 per cent for males and 36 per cent for white females and 40 per cent for Negro females. In the three to six month

period, the largest mean increase was observed for white females (16.3 per cent) and the smallest for Negro females (13.7 per cent), while the values for the two male groups were around 14.6 per cent. From six to twelve months, the means for females (11.9 and 11.5 per cent) exceeded those for males (9.6 and 10.2 per cent).

Greater relative growth was observed for males in all five measurements during the first interval and in weight and crown-sole length during the second. During the six to twelve month period, the mean per cent gains were greater for females in weight, hip breadth, and calf circumference. Higher means were observed for Negroes in weight and crown-sole length between birth and three months of age and in weight during the six to twelve month period. White infants had the larger relative growth in hip breadth during the first two intervals and in weight during the second three month period.

The coefficients of correlation between the increments of the different measurements during each time period are given in Table 16. As before, each coefficient is the weighted average of the coefficients for the four race-sex groups. Sixteen of the 130 sets of correlations were found to be non-homogeneous, and their coefficients are shown in italics in Table 16 with the correlations for each race-sex group given in Table 17.

During the interval from birth to three months, the highest correlations between increments in the measurements were observed for weight and calf circumference (.72) and weight and chest circumference (*.60*). The lowest coefficients were between gain in rump-sole length and gain in each of the other measurements, for which the range of value was between .04 and – *.14*. Most of the other correlations were between .30 and .50.

In the following period, from the three month to the six month examination, the highest correlation between the increments was again between those for weight and calf circumference (.71), while none of the other coefficients exceeded .47. The correlations involving the growth of rump-sole length

Table 16. Coefficients of correlation between increments of the measurements during each period.

Measurement	Birth to Three Mos.	Three to Six Mos.	Six to Twelve Mos.	Birth to Six Mos.	Birth to Twelve Mos.	Birth to Three Mos.	Three to Six Mos.	Six to Twelve Mos.	Birth to Six Mos.	Birth to Twelve Mos.	Birth to Three Mos.	Three to Six Mos.	Six to Twelve Mos.	Birth to Six Mos.	Birth to Twelve Mos.	Birth to Three Mos.	Three to Six Mos.	Six to Twelve Mos.	Birth to Six Mos.	Birth to Twelve Mos.
	Weight					Chest Circumference					Crown-Sole Length					Crown-Rump Length				
Weight	—	—	—	—	—	*.60*	.43	.46	.63	.64	.45	.37	.37	.53	.54	.50	.43	.35	.57	.62
Chest Circumference	.60	.43	.46	.63	.64	—	—	—	—	—	.38	.16	.10	.41	.39	*.48*	.30	.10	.48	.56
Crown-Sole Length	.45	.37	.37	.53	.54	.38	.16	.10	.41	.39	—	—	—	—	—	—	—	—	—	—
Crown-Rump Length	.50	.43	.35	.57	.62	*.48*	.30	.10	.48	.56	—	—	—	—	—	—	—	—	—	—
Rump-Sole Length	.04	.07	.04	.10	.18	−.01	−.05	−.04	.04	.11	—	—	—	—	—	*−.14*	*−.07*	−.26	−.07	.00
Hip Breadth	*.45*	.47	.41	.57	.61	*.46*	.31	.27	.50	.58	.25	.26	.22	.40	.45	.33	.26	.19	*.43*	*.51*
Head Circumference	.35	.31	.28	.37	.42	.33	.23	.21	.40	.38	*.24*	.23	.13	.32	.35	.32	.27	.27	.40	.44
Calf Circumference	.72	.71	.55	*.75*	*.83*	*.48*	*.32*	*.19*	.54	.66	.34	.20	.20	.46	.39	.36	.27	.35	.46	.56
	Rump-Sole Length					Hip Breadth					Head Circumference					Calf Circumference				
Weight	.04	.07	.04	.10	.18	*.45*	.47	.41	.57	.61	.35	.31	.28	.37	.42	.72	.71	.55	*.75*	*.83*
Chest Circumference	−.01	−.05	−.04	.04	.11	*.46*	.31	.27	.50	.58	.33	.23	.21	.40	.38	*.48*	*.32*	*.19*	.54	.66
Crown-Sole Length	—	—	—	—	—	.25	.26	.22	.40	.45	*.24*	.23	.13	.32	.35	.34	.20	.20	.46	.39
Crown-Rump Length	*−.14*	*−.07*	−.26	−.07	.00	.33	.26	.19	*.43*	*.51*	.32	.27	.27	.40	.44	.36	.27	.35	.46	.56
Rump-Sole Length	—	—	—	—	—	−.03	.07	.06	.11	.16	−.03	*.07*	−.08	.05	.01	.01	.01	−.08	.08	.00
Hip Breadth	−.03	.07	.06	.11	.16	—	—	—	—	—	.28	.17	.14	.30	.31	*.53*	.28	.27	.64	.64
Head Circumference	−.03	*.07*	−.08	.05	.01	.28	.17	.14	.30	.31	—	—	—	—	—	.36	.28	.29	.36	.45
Calf Circumference	.01	.01	−.08	.08	.00	*.53*	.28	.27	.64	.64	.36	.28	.29	.36	.45	—	—	—	—	—

Number

Measurements	Birth to Three Mos.	Three to Six Mos.	Six to Twelve Mos.	Birth to Six Mos.	Birth to Twelve Mos.	Measurements	Birth to Three Mos.	Three to Six Mos.	Six to Twelve Mos.	Birth to Six Mos.	Birth to Twelve Mos.	Measurements	Birth to Three Mos.	Three to Six Mos.	Six to Twelve Mos.	Birth to Six Mos.	Birth to Twelve Mos.
Wt. × Ch.	686	646	406	610	367	Ch. × R-S	586	554	351	527	310	C-R × Head	586	559	356	530	314
Wt. × C-S	689	653	410	616	375	Ch. × Hip	557	538	342	491	293	C-R × Calf	191	207	133	193	92
Wt. × C-R	580	554	349	528	309	Ch. × Head	692	651	413	613	373	R-S × Hip	549	536	343	488	293
Wt. × R-S	580	554	349	528	309	Ch. × Calf	193	204	132	193	90	R-S × Head	586	559	356	530	314
Wt. × Hip	550	537	341	490	291	C-S × Hip	556	542	347	492	297	R-S × Calf	191	207	133	193	92
Wt. × Head	685	653	411	613	372	C-S × Head	690	658	417	614	378	Hip × Head	557	542	347	493	297
Wt. × Calf	190	207	132	194	92	C-S × Calf	193	209	133	195	92	Hip × Calf	182	205	129	181	91
Ch. × C-S	691	651	412	611	373	C-R × R-S	587	559	356	531	315	Head × Calf	193	209	133	196	92
Ch. × C-R	586	554	351	527	310	C-R × Hip	549	536	343	488	293						

Note: Coefficients in italics are based on coefficients by race and sex which are not homogeneous.

were all between .07 and −.07. The other coefficients were mostly between .20 and .40. In general, the correlation coefficients between the increments of growth during this period were either equal to or less than the corresponding values for the preceding three month period.

The association between gain in the measurements during the six to twelve month interval was, in most instances, lower than that during the previous three months. The highest correlations were found between increase in weight and calf circumference (.55), weight and chest circumference (.46) and weight and hip breadth (.41). The lowest correlations were,

Table 17. Non-homogeneous correlations by race and sex between increments during each period.

Measurements	Period	Correlation Coefficient				Number			
		White Male	White Female	Negro Male	Negro Female	White Male	White Female	Negro Male	Negro Female
Weight and Chest Circumference	Birth–3 Months	.52	.64	.58	.71	239	205	130	112
Weight and Hip Breadth	Birth–3 Months	.36	.42	.39	.68	188	164	105	93
Chest Circumference and Crown-Rump Length	Birth–3 Months	.45	.36	.57	.61	204	172	111	99
Chest Circumference and Hip Breadth	Birth–3 Months	.39	.40	.46	.65	190	167	106	94
Chest Circumference and Calf Circumference	Birth–3 Months	.28	.58	.31	.70	51	41	52	49
Crown-Sole Length and Head Circumference	Birth–3 Months	.23	.37	.06	.20	239	207	131	113
Crown-Rump Length and Rump-Sole Length	Birth–3 Months	−.30	.03	−.21	.00	205	172	111	99
Calf Circumference and Hip Breadth	Birth–3 Months	.27	.67	.44	.69	46	40	50	46
Chest Circumference and Calf Circumference	3–6 Months	.16	.32	.60	.14	56	47	54	47
Rump-Sole Length and Crown-Rump Length	3–6 Months	−.01	−.14	−.27	.18	188	164	112	95
Rump-Sole Length and Head Circumference	3–6 Months	.23	−.05	.02	−.01	188	164	112	95
Chest Circumference and Calf Circumference	6–12 Months	.13	.58	.19	−.14	42	29	30	31
Weight and Calf Circumference	Birth–6 Months	.62	.83	.70	.84	57	39	51	47
Crown-Rump Length and Hip Breadth	Birth–6 Months	.31	.40	.57	.52	171	134	97	86
Weight and Calf Circumference	Birth–12 Months	.66	.94	.78	.87	25	17	24	26
Crown-Rump Length and Hip Breadth	Birth–12 Months	.31	.57	.55	.67	96	78	61	58

again, those between the gain in each measurement and gain in rump-sole length, all of which, with one exception were near zero. The exception was the correlation between growth in rump-sole and crown-rump length for which the coefficient was – .26. Almost all the other coefficients were between .10 and .30.

The correlations for the period, birth to six months, tended to be slightly higher than those for the birth to three month interval. The largest values were those for gain in weight and calf circumference (.75) weight and chest circumference (.63) and hip breadth and calf circumference (.64). The correlations with gain in rump-sole length were low (.11 to – .07). All the other coefficients were above .40 with the exception of those involving head circumference which were between .30 and .40.

The coefficients of correlation between growth in each measurement over the entire first year of life were slightly larger than the corresponding values during the other two periods starting at birth. Six coefficients were over .60, those of the increments in weight and calf circumference, chest circumference, crown-rump length, and hip breadth, and the increments in calf circumference and both chest circumference and hip breadth. Except for the correlations involving rump-sole length, the other coefficients were above .30.

The correlations between the increments which were not homogeneous by race and sex are shown in Table 17. Half of these sets of coefficients are for the interval birth to three months. In six of these sets the correlations for females were higher than those for males and, hence, the combined coefficient was an underestimate for the former group and an overestimate for the latter. These sets are: in the birth to three month period, weight and chest circumference, chest and calf circumference, crown-sole length and head circumference, and calf circumference and hip breadth; and in the birth to six and twelve month intervals, weight and calf circumference. The correlations for males were greater than those for females for

crown-rump and rump-sole length during the initial period, and those for Negroes exceeded those for the white groups for chest circumference and crown-rump length in the first interval and crown-rump length and hip breadth in the birth to six month period. The other sets of correlations were in no consistent pattern with respect to differences by race and sex.

Although the coefficients of correlation between the increments in each period were generally significantly different from zero, it seems evident that the association between the growth of most of these body dimensions is not strong. As might be expected, the measurement whose increase was most closely correlated with increase in the other measurements was weight. When the highest correlation of the increments of a measurement was not with weight gain, it was usually with the gain in calf circumference, which, in turn, was more highly correlated with weight gain than were increases in any other dimension.

The low or non-existent association between increase in rump-sole length and increases in the other measurements is puzzling. If it is a correct expression of the relationships it implies that the growth in length of the legs during infancy is almost completely independent of the growth in any of the other body measurements considered here. On the other hand, the fact that rump-sole length is the only measurement not observed directly but is obtained by subtraction of crown-rump length from crown-sole length suggests the possibility that errors of some magnitude may have been introduced by this procedure.

The coefficients of correlation between the increments in each measurement in one period with the increments of the same measurement in the following period are given in Table 18. The four sets of correlations by race and sex which were found to be non-homogeneous are shown in Table 19. All coefficients were negative except those for weight and one coefficient for head circumference. While none were higher than $-.39$, all were significantly different from zero, with the excep-

tion of the four which were less than ±.10. The negative values, while low, are suggestive of a tendency for large or small increases in a body measurement during one period to be followed by relatively small or large increases, respectively, in the next period. The higher correlations for rump-sole gain indicate that this tendency is most marked for this measurement. On the other hand, large or small weight gains in one period are associated, to some degree, with similar increases in the other periods.

The correlations for each race-sex group in Table 19 for the non-homogenous sets of correlations show that for white babies the correlation of increments between the first two three-month periods were definitely negative for chest circumference, rump-sole length, and calf circumference, and posi-

Table 18. Coefficients of correlation between increments of each measurement.

Measurement	Birth to Three Months and Three to Six Months	Three to Six Months and Six to Twelve Months	Birth to Six Months and Six to Twelve Months
	CORRELATION COEFFICIENT		
Weight	.23	.24	.20
Chest Circumference	*−.16*	−.14	−.18
Crown-Sole Length	−.13	−.23	−.13
Crown-Rump Length	−.10	−.23	−.20
Rump-Sole Length	*−.22*	−.38	−.39
Hip Breadth	−.03	−.15	−.19
Head Circumference	*.06*	−.11	−.11
Calf Circumference	*−.06*	−.01	−.33
	NUMBER		
Weight	*666*	420	427
Chest Circumference	572	408	364
Crown-Sole Length	579	412	372
Crown-Rump Length	490	336	306
Rump-Sole Length	490	336	306
Hip Breadth	455	321	284
Head Circumference	575	413	369
Calf Circumference	163	109	88

Note: Coefficients in italics are based on coefficients by race and sex which are not homogeneous.

Measurement	Correlation Coefficient				Number			
	White Male	White Female	Negro Male	Negro Female	White Male	White Female	Negro Male	Negro Female
Chest Circumference	−.32	−.17	−.01	.02	190	167	116	99
Rump-Sole Length	−.33	−.31	−.02	−.07	167	138	97	88
Head Circumference	.11	.21	−.06	−.17	190	167	117	101
Calf Circumference	−.10	−.25	−.27	.32	40	32	47	44

Table 19. Non-homogeneous correlations by race and sex between increments in the birth to three months and three to six month periods.

tive for head circumference. Among Negro infants, these coefficients were either near zero or, in the case of calf circumference, differed between the two sex groups.

Summary

Data on the measurements of weight, chest circumference, crown-sole length, crown-rump length, rump-sole length, hip breadth, head circumference, and calf circumference at birth and three, six, and twelve months of age are presented for 1,391 white and Negro infants.

The mean values of these measurements are almost always larger for males than for females at each age. The means for the white babies are usually larger than those for Negroes of the same sex for weight, chest circumference, crown-rump length, hip breadth, and calf circumference, and are smaller for rump-sole length and head circumference.

The mean per cent increase from birth to each subsequent age is given for five of the measurements. The largest relative increases were found for weight, followed by calf circumference, hip breadth, crown-sole length, and chest circumference.

Correlation coefficients between the measurements at each age indicate that the size of each body dimension is more highly correlated with weight than with any of the other dimensions. The lowest correlations were those between rump-sole length and the other measurements.

The correlations between the same measurement at the different ages are shown. The highest correlations are those be-

tween the observations at three and six months and six and twelve months. The largest correlations between the birth observations and subsequent measurements are found for length and head circumference.

The mean and quartile value of the increments in each measurement between each examination are given. From birth to the later ages, the average increments were usually greater for males than for females. The difference by race and sex during the other intervals were less consistent.

Comparison of mean per cent gain in each interval for five of the measurements indicated greater growth for males during the first three months of life. From six to twelve months, the mean per cent increase in weight, hip breadth, and calf circumference was larger for females than for males.

The correlation coefficients between the increments in each interval are presented. Weight gain is most highly correlated with the increments of the other measurements while the association of growth in rump-sole length with the other increments is usually near zero.

Correlations of the increments of a measurement in one period with those of the same measurement in another period are, with the exception of those for weight gain, usually negative.

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THE INFLUENCE OF WAR AND POST-WAR CONDITIONS ON THE TEETH OF NORWEGIAN SCHOOL CHILDREN

III. DISCUSSION OF FOOD SUPPLY AND DENTAL CONDITION IN NORWAY AND OTHER EUROPEAN COUNTRIES[1]

GUTTORM TOVERUD[2]

INTRODUCTION

IN two previous reports (Toverud 1956, 1957) changes in the condition of the teeth of Norwegian school children during the War and post-war years were described in detail. The findings reported were from a nation-wide investigation conducted by the Pedodontic Department of the Norwegian State Dental School with the cooperation of the dentists in twenty-two school dental clinics in widely separated sections of Norway.

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Reprints of these reports are available through the Milbank Memorial Fund.

Table 35. The caries status of preschool children examined in Blaker, Fet and Skedsmo, Norway, 1939–1953.

Year of examination	Number of Children Examined	Per Cent of Children with Caries	Per Cent of Teeth *dmf*	Per Cent of Tooth Surfaces *dmf*
	3 year old children			
1939	103	88.3	31.7	11.4
1944	120	62.5	16.2	4.1
1945	108	45.4	10.2	2.7
1946	154	52.6	12.5	3.6
1947	159	61.6	15.8	4.5
1948	154	61.0	17.7	5.1
1949	202	74.8	22.7	6.8
1950	201	72.6	23.4	7.7
1952	162	71.0	21.7	6.6
1953	135	80.7	25.7	8.4
	4 year old children			
1939	85	95.3	46.9	21.0
1944	139	79.9	22.3	7.6
1945	121	68.6	17.5	4.7
1946	124	66.1	17.5	5.0
1947	132	71.2	21.3	6.8
1948	134	82.8	27.6	9.4
1949	147	91.2	29.7	9.7
1950	196	89.8	35.3	12.1
1952	145	89.0	34.1	12.8
1953	150	91.3	35.9	13.5
	5 year old children			
1939	100	99.0	55.5	27.3
1944	130	90.0	39.7	15.7
1945	124	82.3	26.6	8.8
1946	116	80.2	24.5	7.4
1947	125	78.4	26.8	9.0
1948	129	79.8	32.3	11.7
1949	142	91.5	36.8	14.2
1950	162	95.1	39.5	15.3
1952	162	96.9	37.7	15.3
1953	114	96.5	48.5	20.7
	6 year old children			
1939	66	100.0	65.3	35.3
1944	118	96.6	47.6	20.7
1945	105	88.6	35.4	13.6
1946	109	91.7	33.1	11.7
1947	104	84.6	31.3	9.4
1948	99	89.9	38.7	15.0
1949	98	89.7	37.0	14.6
1950	143	96.5	48.1	21.6
1952	157	95.5	48.4	21.3
1953	142	99.3	50.6	23.2

The present report summarizes data from other studies in Norway and in various European countries on the amount of dental caries during and after the War and presents data on changes in consumption of different kinds of food during these years. In conclusion, the evidence on the influence of the dietary changes on the condition of the teeth is evaluated and an interpretation is suggested for the observed relationship between food intake and changes in the frequency of caries in the teeth.

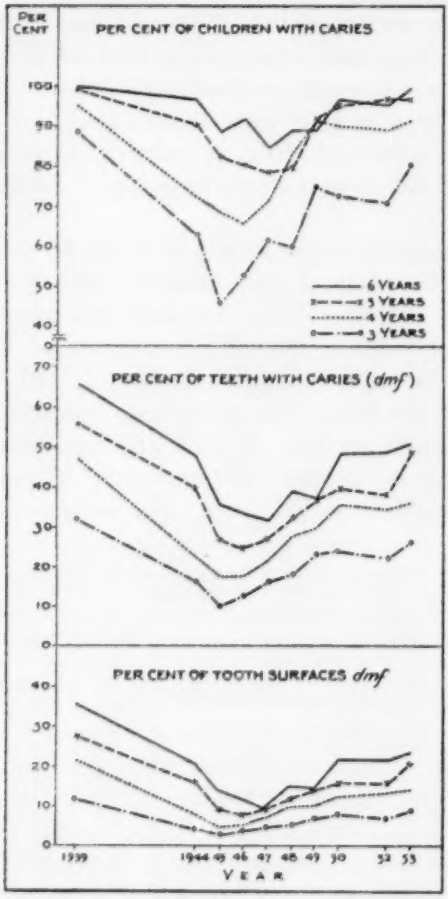


Fig. 41. Caries status of preschool children examined in Blaker, Fet, and Skedsmo, Norway, 1939–1953.

Other Norwegian Studies on the Dental Conditions in Children

In order to further demonstrate the influence of war-time conditions on children's teeth in Norway, some results from other studies will be briefly mentioned in addition to those described in Part I and Part II (Toverud 1956 and 1957).

Caries Frequency in Pre-school Children in the Rural Com-

munities Blaker, Fet, and Skedsmo. In these three small rural communities not far from Oslo, pre-school children have been examined by the staff of the Pedodontic Department since 1939. In Skedsmo, a systematic prophylactic health service for mothers and children was started in 1936 and has been continued ever since. In that community, the pre-school children had a significant decrease in caries frequency from 1936 to 1939. As the caries rates in 1939 were about equal in all three districts, we have combined them in order to have a larger group of children. All three districts have had a dental health program.

Results of annual examinations are shown in Table 35 and Figure 41 for the years 1939 through 1953, with the exception of the years 1940 through 1943 and 1951, when dental examinations were not made in all districts. As will be seen, a considerable decrease in the caries rates took place in 3, 4, 5, and 6 year-old children during the War. The percentage reduction is greatest in rates for tooth surfaces affected and was from 78 to 73 per cent for these age groups. The percentage reduction in caries-affected children is the least. The reductions

Table 36. DMF surfaces in permanent teeth of first grade school children (7 year-olds) in Oslo in the school years from 1929–1930 through 1953–1954.

Year of Examination (October Each Year)	DMF Surfaces		Year of Examination (October Each Year)	DMF Surfaces	
	Per Child	Per 100 Teeth		Per Child	Per 100 Teeth
1929		87.8	1941	5.4	70.1
1930		87.9	1942	5.4	70.3
1931		87.5	1943	3.4	44.6
1932		89.6	1944	2.8	38.6
1933		91.1	1945	2.4	33.4
1934		86.0	1946	2.7	39.7
1935		86.0	1947	3.5	46.4
1936		91.6	1948	3.6	45.2
1937		91.5	1949	3.6	44.2
1938	6.7	86.9	1950	3.9	47.6
1939	6.6	80.3	1951	4.3	49.4
1940	6.7	83.6	1952	4.4	49.3
			1953	4.7	54.3

are 49, 31, 21, and 15 per cent, respectively, in the 3, 4, 5, and 6 year groups. In the youngest age group the minimum rates are in 1945, in the 4 and 5 year-old groups in 1946 or 1947 and in the 6 year-old group in 1947. The increase in caries rate from the lowest figure to that for 1953 is also highest in the youngest group and lowest in the oldest group. The percentage of children with caries increased 78 and 17 per cent at age 3 and age 6, respectively. The increase in *dmf* teeth and *dmf* surfaces also has been least in the oldest group. In no case had the caries rates in 1953 reached those of 1939.

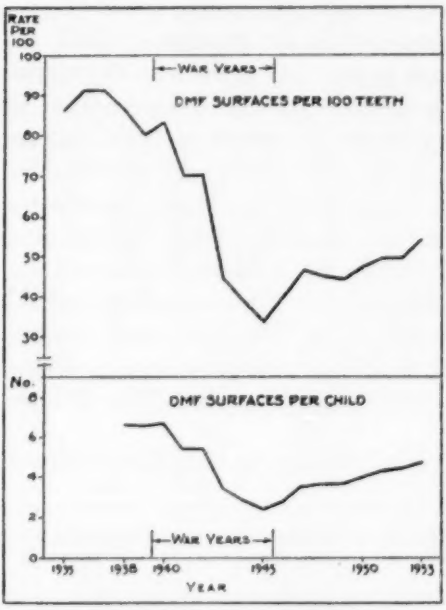


Fig. 42. Carious surfaces in permanent teeth of first grade children (7 years of age) in Oslo, for school years 1935–1936 through 1953–1954 (examinations in October). War years include 1939–1940 through 1944–1945.

These differences between the youngest and the oldest groups in changes in the frequency of caries suggest strongly that the youngest teeth react more readily to changes in the nutritional or environmental conditions than do the older teeth.

Dental Condition of School Children in Oslo. Table 36 and Figure 42 show changes in the caries picture in first grade school children in Oslo from 1929–1930 to 1953–1954.[3] For these children, average age of 7 years, the DMF surfaces per child dropped from 6.7 in 1938–1939 to 2.4 in 1945–1946.

[3] Figures given by courtesy of J. Ramm, Director of the Public Dental Service of Oslo.

Calculated as DMF surfaces per 100 teeth the corresponding figures are 86.9 and 33.4. The reduction is 64 and 62 per cent, respectively.

For children in the sixth and seventh grades, Table 37 gives data on caries activity measured as the increase in DMF surfaces between examinations in the sixth grade and the seventh grade one year later (corresponding to the increase from age 12 to age 13 years). The annual incidence of DMF surfaces decreased from 9.6 per child in 1938–1939 to 2.5 in 1944–1945, and from 37.8 to 9.9 per hundred teeth. This is a reduction of 74 per cent. After the War, the caries rates for first grade children and also the caries activity in 12 to 13 year-old children increased. The incidence of new carious surfaces in 1952–1953 reached the same height as in 1939–1940 for 13 year-old children. The prevalence of DMF surfaces in first grade children in 1953–1954 is between the values for 1942–1943 and 1943–1944.

As will be seen, the caries activity in the 12–13 year-old

Table 37. Increase in DMF surfaces of teeth for children examined in the 6th grade and a year later in the 7th grade in Oslo, school-years 1938–1939 through 1952–1953.

Year of 7th Grade Examination[1] (March of Each Year)	DMF Surfaces per Child	DMF Surfaces per 100 Teeth
1939	9.6	37.8
1940	7.3	28.8
1941	7.3	29.0
1942	4.7	18.6
1943	4.3	16.7
1944	3.5	13.8
1945	2.5	9.9
1946	3.0	11.6
1947	4.7	18.1
1948	6.3	24.2
1949	5.8	22.6
1950	4.7	18.1
1951	5.8	22.4
1952	7.4	28.7
1953	7.8	30.6

[1] The number of children examined each year has varied from about 2,500 to 3,700.

children dropped more readily than did the DMF surfaces in the 7 year-old children.

Fillings Inserted in School Dental Clinics in Norway. The numbers of fillings inserted per child 7–14 years of age in all school dental clinics in Norway in the years 1938–1939 through 1953–1954,[4] shown in Table 38, also throw some light on changes in the dental condition in children in pre-war, war and post-war years. However, it should be stressed that these figures do not describe the complete caries picture for the permanent dentition as they represent only number of fillings. Furthermore, the figures for single years may not be strictly comparable as they are not always based on the number of surfaces filled. In spite of these reservations, the Table demonstrates a pattern of changes in the amount of caries in the whole country very similar to that for Oslo shown by the actual caries rates. The lowest figures for the whole country and for

Table 38. Number of fillings inserted per child, 7–14 years of age, in all school dental clinics in Norway in the years 1938–1939 through 1953–1954.

School Year	Number of Fillings Inserted per Child in the Specified School Year		
	Whole Country[1]	Cities	Villages and Rural Districts
1938–1939	3.88	4.71	3.32
1939–1940	3.61	4.59	3.13
1940–1941	3.56	4.81	2.95
1941–1942	2.72	3.63	2.32
1942–1943	2.36	3.06	1.98
1943–1944	1.98	2.46	1.80
1944–1945	1.80	2.43	1.55
1945–1946	1.78	2.31	1.59
1946–1947	2.28	2.85	2.02
1947–1948	2.64	3.52	2.37
1948–1949	2.80	3.78	2.55
1949–1950	2.97	3.67	2.71
1950–1951	3.26	4.17	2.92
1951–1952	3.46	4.54	3.04
1952–1953	3.69	4.53	3.33
1953–1954	3.88	4.80	3.48

[1] Number of children each year has varied from 143,590 to 297,535.

[4] Figures given by courtesy of the Directorate of Public Health of Norway.

the cities are in 1945–1946 and for the rural and village districts in 1944–1945. The lowest figures for Oslo also occurred within the same two years.

All the published reports from individual school dental clinics for the war and post-war years show the same picture of decreased frequency of caries, and of fillings, during the War and of increases after the War. The changes in caries rates during and after the War demonstrated in Tables 35, 36, and 37 correspond very well to those described in Parts I and II of this report (Toverud 1956 and 1957).

Thus, it has been demonstrated that the dental condition in children 3–14 years of age improved very much during the war years. Unfortunately, no statistical data are at hand to give a picture of the caries frequency in teenagers and adults. But the clinical experience of practicing dentists was that caries activity was lowered at all ages.

In relation to the great beneficial effects on the teeth of wartime conditions, it is of interest to get an overall picture of their influence on the general health status of the Norwegian population.

The Health of the Norwegian Population during World War II. From the report THE INFLUENCE OF WARTIME ON HEALTH CONDITIONS IN NORWAY by Axel Strøm, head of the Institute of Social Medicine, University of Oslo, the following findings relating to effects on health may be listed. (The material available, Strøm writes, is primarily the official statistics on mortality and morbidity, etc., but is also from special investigations.)

A. *Unfavorable Conditions:*

Increase in general mortality.
Increase in mortality from gastric and duodenal ulcers in men but not in women.
Increase in mortality from acute infectious diseases, (after the War, there was a decrease).
Increase in venereal diseases.
Decrease in height and weight of school children.

Moderate loss of weight in adults.
Slight degree of undernourishment, hypovitaminosis A, edema, anemia, nocturia, and amenorrhea.

B. *Favorable Conditions:*

Decrease in mortality during pregnancy, delivery, and puerperium.
Decrease in frequency of stillbirth.
Decrease in neo-natal and infant mortality.
Decrease in mortality from tuberculosis continued.
Decrease in mortality from diabetes. After the War there was an increase.
Decrease in mortality from diseases of the circulatory system and a reduction in hypertension.
Decrease in mortality from malignant tumors. Mortality increased after the War.
Decrease in frequency of hypertrophic tonsils and adenoids in school children. This has increased markedly after the War.
Decrease in frequency of post-operative thrombosis.
Decrease in frequency of dental caries in children.

Strøm writes, "The most serious health problem was infectious diseases. They were the primary cause of the poor health and made the largest contribution to the increase in mortality." Strøm points out, however, that it is doubtful that the changed diet played any significant role in the spread of these diseases with the exception of tuberculosis. Lowered immunity and increased exposure along with poor hygienic conditions must be regarded as more important.

According to this report, the war conditions had a favorable influence on the health of the population in other respects in addition to beneficial effects on the teeth. Diseases showing a decreased morbidity and mortality rate are mainly diseases which may be related to high intake of special foods or to a high total food intake. But unfortunately many diseases increased in frequency as well as in severity during the war years. The total health has to be characterized as subnormal.

Food Consumption in Norway, 1940–1948

Since Norway has to import a great deal of food for both human and animal nutrition, some rationing was introduced at the beginning of World War II in 1939. Rationing of the various foods was introduced as follows:

Sugar and coffee from September, 1939. After 1941 practically no coffee or tea was available.
Flour from April, 1940; and from March, 1941, white wheat flour was only for children up to 2 years of age.
Chocolate and cocoa from fall, 1940.
Meat and bacon from 1940.
Butter and margarine from June, 1940.
Milk and cheese from fall, 1941.
Potatoes from fall, 1942.
Cod liver oil from October, 1942.
The distribution of fruit and vegetables was regulated to a certain degree from September, 1941, and September, 1942; respectively.
The distribution of fresh fish was partly regulated from fall, 1943.
Eggs were not rationed but the production decreased to such an extent that they disappeared from the market.

Because large quantities of food had been stored, rations were rather liberal at the beginning of the War.

The Department of Supply and Rationing has reported on the food production during the War as follows (Stortingsmelding nr. 37, 1945–1946):

Production of milk decreased 35 per cent.
Production of grain decreased 15 per cent.
Production of meat and bacon decreased 50 per cent.
Production of potatoes decreased somewhat.
Production of fruit decreased somewhat.
Production of vegetables increased considerably.
Fish catch decreased 30 per cent.

The daily rations of the various foods for specific categories

Type of Food	Category of Consumers	1941	1942	1943	1944	1945	1946	1947	1948
Milk	Basic Adults	No R	250 S	250 S	250 S	109 S	250	250	250
S = Skim Milk,						141			
All Other	Women, Preg.-Lact.	No R	250 S	250 S	250 S	100 S	1,000	1,000	1,000
Is Whole			750	750	750	900			
	Children 0– 5 Yrs.	No R	750	750	750	750	750	750	750
	6–15 Yrs.	No R	500	500	500	500	500	500	500
	16–18 Yrs.	No R	250 S	250 S	250 S	135 S	500	500	500
			250	250	250	365			
Cheese	All Ages	No R	4.9	2.6	2.2	3.0	4.3	4.1	4.3
Butter and									
Margarine	All Ages	40	30	30	30	38	51	49	45
Meat	All Ages	30	19	8	7	28	36	18	25
Potatoes	All Ages	No R	430	430	430	430	No R	No R	No R
Flour	Basic Adults	220	220	220	200	225	250	250	250
	Children 0– 2 Yrs.	212	212	212	100	125	150	150	150
	3–12 Yrs.	220	220	220	200	225	250	250	250
	13–20 Yrs.	220	220	220	300	325	350	350	350
Sugar	All Ages	43	37	37	34	37	41	40	40
Syrup	All Ages	4.7	3.3	3.6	3.3	1.2	0	2.5	0.8
Chocolate and Cocoa	Children 0–12 Yrs.	No R	0[a]	0[a]	0[a]	1.9	10.6	10.6	10.6
Candy Bars	All Ages	No R	0[a]	0[a]	0[a]	1.0	5.5	6.2	6.9
Canned Fruit									
(Dried)	All Ages	No R	0	0	0	1.2	2.6	3.5	1.8
Cod Liver Oil	Women, Preg.-Lact.	No R	10.0	6.0		10.0	No R	No R	No R
	Children 0–16 Yrs.	No R	3.0	3.0		3.0	No R	No R	No R

[a] There was a very small ration, a negligible amount, of chocolate and candy, 1942–1944.

Table 39. Food rations in Norway, 1941–1948 in grams per person per day.

of consumers are shown in Table 39 for the years 1941–1948.[5]

In order to estimate the total intake of nutrients, one has to add to the rationed foods the unrationed foods which were available. The consumption of fish has been estimated to average 300 gms. per person per day of which one-third may be taken as fat fish such as herring (fresh or salted) and mackerel. The average intake of vegetables (including roots) and of fruits including berries has been estimated at 80 gms. of each.

The Nutritional Value of the Food Intake

In calculating the nutrients in the rationed foods we have made use of Norwegian food tables.

For the very young children, the whole ration of flour and potatoes has been taken into account in calculating the nutri-

[5] I am grateful to Mr. H. Skaarer for his valuable help in calculating the data in Tables 39, 40, and 41.

ents in spite of the fact that these children did not consume that much. This is not important, however, since the amount of other foods was rather liberal for the younger children.

Protein. Table 40 shows that the protein requirement was not met by the rationed foods in the year 1941. Together with the available unrationed foods in that year, the need most probably was covered. For the rest of the period, protein in the rationed foods was sufficient for children 0–5 years. The

Table 40. Protein, fat, carbohydrate and calories per day in rationed foods in Norway, 1941–1948.

Categories of Consumers	Requirements	1941	1942	1943	1944	1945	1946	1947	1948
	PROTEIN—GRAMS PER PERSON								
Basic Adults	70	31	48	45	43	48	47	50	45
Women, Preg.-Lact.	85–100	31	75	72	70	75	74	77	72
Children 0– 2 Yrs.	38	30	65	63	50	56	55	58	53
3– 5 Yrs.	45	31	66	63	61	67	66	69	64
6–12 Yrs.	65	31	57	54	52	58	57	70	65
13–18 Yrs.	80–100	34	60	58	63	68	67	70	65
	FAT, EXCLUDING COD LIVER OIL—GRAMS PER PERSON								
Basic Adults	100	46	34	33	32	47	69	74	66
Women, Preg.-Lact.	100	75	63	62	61	76	98	103	95
Children 0– 2 Yrs.	35	46	63	64	60	70	90	95	87
3– 5 Yrs.	50	47	64	65	61	71	92	96	89
6–12 Yrs.	65	47	54	55	51	61	81	86	78
13–18 Yrs.	120	46	53	52	52	62	80	84	77
	CARBOHYDRATE—GRAMS PER PERSON								
Basic Adults	425	222	305	301	282	300	252	252	253
Women, Preg.-Lact.	425	258	341	337	318	336	288	288	289
Children 0– 2 Yrs.	100	216	324	319	236	255	211	212	212
3– 5 Yrs.	175	222	329	325	306	325	281	282	282
6–12 Yrs.	225–350	222	317	313	294	313	279	270	270
13–18 Yrs.	420	243	338	334	364	383	334	334	335
	CALORIES—NUMBER PER PERSON								
Basic Adults	2,600	1,297	1,636	1,614	1,612	1,835	1,694	1,725	1,647
Women, Preg.-Lact.	2,500–3,000	1,632	2,146	2,124	2,122	2,345	2,204	2,235	2,157
Children 0– 2 Yrs.	1,000	1,403	2,031	1,999	1,600	1,798	1,739	1,770	1,692
3– 5 Yrs.	1,400	1,431	2,059	2,027	1,940	2,138	2,079	2,110	2,032
6–12 Yrs.	2,200	1,632	1,891	1,959	1,772	1,970	1,911	1,942	1,864
13–18 Yrs.	3,000–3,500	1,631	1,980	1,958	2,118	2,291	2,116	2,147	2,069

large consumption of fish alone, an average of 300 gms. adding from 30–40 gms. of protein, provided a surplus for all categories of consumers. The protein from unrationed free vegetables furnished only 1 or 2 grams of protein.

It is safe to state that the intake of protein during the war years was sufficient to meet the standard requirements. This is in accord with the findings of Galtung Hansen and Strøm, (Table 42).

Fat. The low fat content of the rations, excluding cod liver oil, is evident in Table 40. In 1941, it met the standard allowance only for children 0–2 years. For the age group 3–5 years and 0–2 years, the fat content was sufficient in the years 1942–1948. All other groups had a great deficiency of fat from the rationed foods during all the war years. Even with the addition of 3 to 10 gms. per day of cod liver oil during the winter months, the fat requirement was not met for these groups.

The estimated consumption of about 300 gms. of fish daily, consisting of one-third fat and two-thirds lean fish, would not yield more than 12 to 15 gms. of extra fat. Even with this amount, the requirements for persons over 13 years of age were not covered. No other food containing a significant amount of fat was unrationed and available.

In conclusion, it may be stated that the fat requirement was met only for children 0–5 years of age. Children 6–12 years were probably lacking fat to some extent. People over 13 years of age were lacking fat to a high degree. This also is in accord with the findings of Galtung Hansen and Strøm.

Carbohydrate. From Table 40, it is seen that the rationed foods in 1941 did not satisfy the requirement for carbohydrates except for children 0–5 years of age. Unrationed and available foods in that year should have been sufficient to meet the need for carbohydrates for all groups. During the rest of the war years, only vegetables and fruits, including berries, were available to supply additional carbohydrate for older children and adults. The estimated consumption of these did not furnish more than 15 to 20 gms. of carbohydrate.

Thus the standard requirements for carbohydrate were fully met only for children 0–5 years. The oldest half of the age group, 6 to 12 years had, no doubt, too low an intake. The deficiency of carbohydrates was even greater for the rest of the population.

The low intake of fat and carbohydrate is probably the main cause of the decrease in weight and height in children over 7 years of age during the war period. Loss of weight was also rather common in adults.

Calories. Table 40 shows that the rationed foods, cod liver oil excluded, in 1941 met the caloric requirement only for children 0 to 5 years. Unrationed foods available at that time can be considered sufficient to have met the requirements for the other groups. The possible sources for making up the deficit in calories from rationed foods during 1942–1945 were cod liver oil, fish, vegetables, and fruit. Based on the assumed consumption of these items, the extra calories available may have amounted to about 350. With these additional calories, the age group 6 to 12 years may have had sufficient calories, but the older groups, except pregnant women, still had a large deficit.

In addition to the rationed food and unrationed home-produced foods, very nourishing foods were sent the Norwegian population from Denmark and Sweden. These humanitarian and very generous gifts were given during the last three and one-half years of the War and it has been estimated by the Department of Supply and Rationing that they furnished about 75 calories per person per day. This food was distributed chiefly to young people in cities and industrial areas.

Furthermore, a certain percentage of the population was able to get some food on the black market from food producers. This was chiefly farm products such as meat, bacon, milk, butter, eggs, and flour. It is not known how much these foods may have added to the legal ration, but estimates are from 100 to 200 calories per person per day during the last three war years.

Altogether the number of calories which may have been consumed by a certain portion of the population during the last three years of the War may be estimated to have been nearly 600 in addition to those obtained from rationed foods. Even with this maximum addition, total calories would not have exceeded 2,300 to 2,900 for the older school children whose requirement is more than 3,000 calories a day. For the basic adults, total calories were not more than 2,300 in 1942, 1943, and 1944.

The Department of Supply and Rationing has estimated the caloric value of the rationed foods to amount to:

	Calories
1940, first half	1,198
1940, second half	1,428
1941	1,273
1942	1,501
1943	1,468
1944, first half	1,428
1944, second half	1,315
1945, January–April	1,349

As will be noted, these figures are lower than those in Table 40. The explanation for this may be that estimates by the Department are based on the overall amounts rationed for the year, whereas our figures are based on the actual amount of food given out, including all extra rations.

This deficit in calories is in accord with the feeling of hunger experienced by most of the older children, teenagers, and adults. Families with young children were better off than families with children in the pre-puberty and puberty ages. The former had some surplus from the ration for very young children.

Calcium. As shown in Table 41, foods rationed in 1941 supplied very little calcium; but it may be taken for granted that the calcium requirements were met by all groups through the use of unrationed foods, milk and cheese particularly. In 1942, calcium values were low, except in the rations for children 0 to

Table 41. Mineral and vitamin content of daily ration of foods in Norway, 1941–1948.

Categories of Consumers	Requirements	1941	1942	1943	1944	1945	1946	1947	1948
	CALCIUM—GRAMS PER PERSON								
Basic Adults	0.8	0.07	0.45	0.78	0.74	0.80	0.81	0.40	0.40
Women, Preg.-Lact.	1.5–2.0	0.07	1.35	1.68	1.67	1.70	1.71	1.30	1.30
Children 0– 2 Yrs.	1.0	0.06	1.05	1.37	1.15	1.21	1.25	1.01	1.01
3– 5 Yrs.	1.0	0.07	1.05	1.38	1.34	1.64	1.44	1.04	1.04
6–12 Yrs.	1.0–1.2	0.07	0.75	1.08	1.04	1.34	1.14	0.74	0.74
13–18 Yrs.	1.4	0.07	0.75	1.08	1.23	1.28	1.30	0.74	0.74
	PHOSPHORUS—GRAMS PER PERSON								
Basic Adults	1.0	0.83	1.38	1.34	1.27	1.39	1.31	1.36	1.30
Women, Preg.-Lact.	2.0	0.83	2.13	2.09	2.02	2.14	2.06	2.11	2.05
Children 0– 2 Yrs.	1.0	0.81	1.81	1.82	1.42	1.54	1.46	1.51	1.45
3– 5 Yrs.	1.0	0.84	1.84	1.85	1.77	1.89	1.81	1.86	1.80
6–12 Yrs.	1.0–1.3	0.84	1.59	1.60	1.52	1.64	1.56	1.61	1.55
13–18 Yrs.	1.3	0.84	1.63	1.59	1.87	1.99	1.91	1.96	1.91
	IRON—MILLIGRAMS PER PERSON								
Basic Adults	12	7.6	10.6	10.3	9.6	10.7	8.5	9.3	8.4
Women, Preg.-Lact.	15	7.6	11.4	11.1	10.4	11.5	9.3	10.1	9.2
Children 0– 2 Yrs.	7	7.4	11.3	11.0	7.5	9.1	7.5	8.1	7.2
3– 5 Yrs.	8	7.6	11.5	11.2	10.5	11.1	10.5	11.1	10.2
6–12 Yrs.	11	7.6	11.2	10.9	10.2	10.8	10.2	10.8	9.9
13–18 Yrs.	15	7.6	11.3	10.9	13.3	14.6	12.4	12.9	12.2
	VITAMIN A, EXCLUDING COD LIVER OIL—I. U. PER PERSON								
Basic Adults	2,500	129	293	281	289	596	432	429	420
Women, Preg.-Lact.	4,000	129	1,193	1,181	1,189	1,507	1,332	1,329	1,320
Children 0– 5 Yrs.	1,250	129	1,193	1,181	1,189	1,327	1,032	1,029	1,020
6–15 Yrs.	2,500	129	893	881	889	1,027	732	729	720
16–18 Yrs.	2,500	129	593	581	589	871	732	729	720
	VITAMIN D, EXCLUDING COD LIVER OIL—I. U. PER PERSON								
Basic Adults	400	3	5	4	4	5	3	3	3
Women, Preg.-Lact.	400	3	29	28	27	28	26	26	26
Children 0– 5 Yrs.	400	3	29	28	27	28	26	26	26
6–15 Yrs.	400	3	21	20	19	20	18	18	18
16–18 Yrs.	400	3	13	12	11	12	12	12	12
	VITAMIN C—MILLIGRAMS PER PERSON								
Basic Adults	30	0	53	53	53	53	2	2	2
Women, Preg.-Lact.	50–75	0	60	60	60	60	9	9	9
Children 0– 5 Yrs.	30	0	58	58	58	58	7	7	7
6–18 Yrs.	50	0	56	56	56	56	5	5	5

5 years, and it is hard to believe that persons in other age groups could meet their requirements through the addition of unrationed foods. In 1943 through 1946, 0.4 per cent calcium carbonate was added to the flour, enriching the flour with 0.16 gm. of calcium per 100 gms. of flour. By this addition, the need for calcium was met for all categories of consumers. During 1947 and 1948, unrationed foods were so plentiful that calcium needs, without doubt, were covered.

It may be concluded that calcium requirements were covered for all categories of consumers during this period with the possible exception of 1942. This is in good harmony with the studies of Galtung Hansen and Strøm, (Table 42).

The milk producers were allowed to keep for home use at least 750 milliliters whole milk per person. This supplied 1.00 gm. of calcium.

In a discussion of the calcium content of the food, it should be mentioned that the high extraction flour (up to 95 per cent) contained a good deal of phytic acid, particularly when oats were added to the bread flour. As is well known, phytic acid interferes with the absorption of calcium and iron. However, as has been shown by Hoff-Jørgensen and co-workers, 1946, prolonged intake of bread made of high extraction flour improved the absorption of calcium in children. Harris, 1955, writes: "The extent to which man can utilize the inositol of phytic acid is not known. On the basis of studies on other species it is probable that appreciable amounts of phytic acid are hydrolyzed in the human intestinal tract." Harris further writes: ". . . the effects of food phytates upon calcium absorption can be masked, partially or completely, by the presence of an abundance of (a) calcium or (b) Vitamin D in the diet. . . ." On the basis of these findings and the constant use of such flour during the war years it seems likely that the phytic acid has not significantly interfered with calcium metabolism.

Phosphorus. Table 41 shows that the food rations contained sufficient phosphorus to meet the requirements of all categories

of consumers except in 1941, when many foods including milk were not rationed.

Iron. Although the rationed foods in 1941 satisfied the requirement for iron only for ages 0 to 2 years, added to the unrationed and at that time available food, the total supply of food should have met the needs of all categories of consumers. For the other years, rations met the needs of age groups 0 to 2 and 3 to 5 years. The estimated consumption of unrationed foods such as fish, vegetables, and fruit, added at least 4 mgms. of iron; and during the last three years, potatoes were not rationed and would supply 0.6 mgm. of iron per hundred gms. The effect of phytic acid on the absorption of iron is similar to that found concerning calcium.

A conclusion that the requirement for iron was met for all categories of consumers during the War seems justified. This also agrees with the studies of Galtung Hansen and Strøm.

Vitamin A. Table 41 shows that rationed foods, cod liver oil excluded, did not furnish a sufficient amount of vitamin A for any group in any of the years listed, except for children 0–5 years of age in 1945. In 1941, it may be taken for granted that the requirement for vitamin A was met by the ration plus unrationed and available foods, including cod liver oil. In the years 1942–1945, during the months October to May, the cod liver oil rations were 6 to 10 gms. to pregnant and lactating women and about 3 gms. to children 0 to 16 years, and this alone should have met the requirements of these groups during these months of the year. Ordinary cod liver oil in Norway contains 750 I.U. vitamin A and 70 I.U. vitamin D per gram. In addition to the ration of cod liver oil, large quantities could be obtained from other sources and were used both by children and adults. It has been estimated that the total cod liver oil production for the Norwegian population was enough to furnish about 5 gms. daily for each person through the whole year.

In 1946, 1947, and 1948 the consumption of cod liver oil decreased somewhat. On the other hand, food was more plentiful.

The high consumption of unrationed foods such as fat fish and leafy and root vegetables would give the older children and adults at least 1,000 I.U. of vitamin A per day.

It should be safe to conclude that children and pregnant and lactating women, at least, did not suffer from lack of vitamin A if they consumed a liberal amount of cod liver oil. As mentioned elsewhere, symptoms of A deficiency have been observed in adults during the War.

Vitamin D. The very low content of vitamin D in the rationed foods, cod liver oil excluded, is shown in Table 41. The consumption of 5–10 gms. of cod liver oil containing 70 I.U. vitamin D per gram, as described in the comments on vitamin A intake, should have furnished sufficient vitamin D. The high consumption of fat fish, for instance, mackerel and herring containing from 1,000–1,500 I.U. vitamin D per 100 gms. should also suffice. As stated before, it has been estimated that about one-third of the total fish consumption consisted of the vitamin D-rich fish.

It seems safe to state that there was no lack of vitamin D in the food available in the years 1941–1948. The conclusions as to vitamin A and D correspond very well with the findings of Galtung Hansen and Strøm, (Table 42).

Vitamin C. The rationed foods in 1941 did not furnish any vitamin C. However, from unrationed potatoes, vegetables, and fruits in 1941 and also in 1946, 1947, and 1948, one may assume that the requirements were met. In 1942–1945, the high potato ration contained the required amount for basic adult consumers and for children, except during the last months before the new crop. For lactating women, vitamin C from this source may have been too little. Unrationed fruits and vegetables, particularly turnips (rutabaga) supplied such large amounts of vitamin C that the required amount was met without the whole ration of potato.

On the average the food available should have satisfied the requirement for vitamin C for all categories of consumers, with exception of a few months just before new vegetables and po-

tatoes were available and in the northern part of the country.

Vitamin B_1. During the war years, the flour was of 95 per cent extraction with the high vitamin B_1 content of about 0.5 mgm. per 100 gms. flour. This furnished 1.1 mgm. of vitamin B_1 for the basic adult consumer. The high potato ration of 430 gms. added 0.4 mgm. of B_1. Thus, the standard basic requirement for this vitamin was met by these two foods alone. When the vitamin B_1 content of other rationed foods and of the unrationed foods is included even the highest requirements of up to 2 mgms. were met. Figures for the amount of vitamin B_1 in the ration for various population groups would be superfluous.

In 1942, Diesen, Chief Medical Officer of Oslo, reported on the nutritional value of the rationed foods for the third quarter of 1942. He states: For pre-school children, the ration supplied a sufficient amount to meet the need for calories, protein, fat, carbohydrate, calcium, phosphorus, iron, vitamins A, B_1, C, and D. For children above 7 years of age, the calorie supply from the rationed foods was far below the need, so also was the amount of fat, protein, and, to a lesser degree, of carbohydrate. The requirement for phosphorus was met, the supply of calcium was somewhat below requirement, and the supply of iron was still more deficient. The minimum requirements of vitamins A, B_1, C, and D were met. The food rations for school-age children were particularly low in iron, fat and carbohydrate; and it was very difficult to make up the deficit of fat and iron and probably also of carbohydrate with available unrationed foods.

Special Diet Surveys. Besides these estimates of the dietary conditions based on the rationing system and what other foods one could expect to be available, two dietary studies on the actual amount of food used by families were conducted during the war years. Such studies, of course, give more real information as to what people actually had to eat.

The most elaborate study was that carried out by Galtung

Hansen (1947) from February, 1941, to July, 1945, by making fourteen different surveys. From twenty-nine to fifty families in Oslo and surroundings were studied three times a year. These studies are of special interest because many of the same families were studied by the same author in 1936–1937.

The other study was carried out by A. Strøm (1948) in two industrial concerns in Oslo and during five and three study periods and in two places in the southern part of Norway for one period. Altogether fifty-three families participated, comprising 184 persons of whom fifty-seven were below 15 years of age. The study periods were of fourteen days duration.

Strøm (1954) has listed the results of the study of Galtung Hansen and of his own studies in such a way that they may be compared. The findings are reproduced in Table 42. With respect to the consumption of various foods, the studies of Galtung Hansen in the period February, 1942, to April, 1945, and those of Strøm in the period November, 1942, to May, 1945, show about the same results. When the amount of food consumed during the war years is compared with that in 1936–1937, a big decrease in the following foods is found: meat, milk, cheese, fat, fruit etc. and sugar, including syrup. An increase took place in consumption of fish, flour and cereals, bread, potatoes, fresh vegetables, and cod liver oil.

The study of Galtung Hansen made soon after the liberation in May–July, 1945, demonstrates an increase over the wartime consumption of meat, milk, fat, eggs, bread and flour and a decrease in consumption of fish, fresh vegetables, and fruit. The overall picture of the changes is towards the pre-war condition.

Table 42 also gives the nutritional value of the food consumed. In this, too, there is rather close agreement between the results of the two authors. Comparing the war values with the pre-war values, the main differences are: reduced calories, fat, protein, and calcium and increased carbohydrate and phosphorus.

Except for calories and fat, values for the other nutrients are within the ranges for accepted standard values. Galtung Han-

sen has calculated that the proportion of total calories from fat dropped from 40 per cent before the War to 22 to 25 per cent during the War. On the other hand, the protein calories showed an increase from 13 per cent to 14–16 per cent of the total calories.

The studies of Galtung Hansen from May to July, 1945, after

Table 42. Food consumption and nutritive content of diets reported from special surveys by Galtung Hansen and by Strøm.

Kind of Food and Nutrient	Galtung Hansen		Strøm	Galtung Hansen
	1936–1937	February, 1942–April, 1945	November, 1942–May, 1945	May–July, 1945
	Grams of food per consumption unit per day			
Meat and Meat Products	158	38	32	97
Fish and Fish Products	99	300	292	208
Total Milk	644	471	403	615
Whole Milk	541	331	248	487
Skimmed Milk	62	137	135	127
Condensed Milk and Cream	41	3	20	1
Butter	71		22	
Margarine and Other Fats	60	45	24	73
Cod Liver Oil	—	3	4	—
Cheese	30	8	12	7
Eggs	39	2	2	11
Bread	288	329	322	354
Flour, Cereals	62	109	106	176
Potatoes	269	510	558	467
Fresh Vegetables	88	166	170	29
Peas and Beans	9	4	6	10
Fruit, Berries, Preserves, Fruit Juices	159	53	62	26
Sugar, Syrup	71	42	36	39
Coffee	17	0	0	5
	Nutrient value per consumption unit per day			
Calories	3,475	2,873	2,849	3,677
Total Proteins Gms.	115	104	93	112
Animal Proteins Gms.	60	60	56	60
Fat Gms.	159	78	71	138
Carbohydrates Gms.	395	444	429	499
Calcium Gms.	1.6	1.3	1.3	1.5
Phosphorus Gms.	1.9	2.4	2.1	2.5
Iron Mgms.	17	20	14	20
Vitamin A IU	—	6,087	4,111	3,753
Vitamin B_1 IU	—	731	720	680
Vitamin C Mgms.	—	87	98	30
Vitamin D IU	—	1,326	1,107	781

the liberation, show higher nutrient values than those during the War except for vitamins.

Both Galtung Hansen and Strøm conclude that the dietary studies showed that the diet during the War was relatively satisfactory qualitatively but not quantitatively. Values from these studies are surprisingly high when compared with the estimated nutrients in Table 41 based on rationed food and unrationed food. Galtung Hansen writes, however, that of the 2,700–2,900 calories, 300–400 were obtained from the black market.

An interesting picture of the changes in food consumption after the War will be seen in Table 43. This table, taken from

Table 43. Foods consumed by 452 families of wage earners in 18 cities and 13 industrial centers in 1947–1948, and by 100 similar families in these districts in 1951–1952. (*From* Statistiske Beretninger, 1954.)

Kind of Food	Grams[1] per Consumption Unit per Day		Per Cent Change from 1947–1948 to 1951–1952
	1947–1948	1951–1952	
Meat and Meat Products	91.6	93.5	+2.1
Bacon	19.5	19.2	−1.5
Fish and Fish Products	132.5	89	−32.8
Milk: Whole, Condensed and Cream	852.0	832.8	−2.2
Butter	12.4	9.9	−20.0
Margarine and Fat	59.7	69.6	+16.6
Cheese	13.5	29.7	+119.2
Eggs	23.8	28	+17.4
Flour	80.7	74.6	−7.5
Bread: Soft	229.1	194	−15.3
Bread: Hard and Cakes	37.9	29.1	−23.2
Potatoes	336.8	295.5	−12.3
Cabbage and Carrots	65.8	62.8	−4.6
Fruit: Apples, Pears and Plums	49.8	47.2	−5.2
Fruit: Citrus	16.7	28.8	+71.9
Fruit: Dried	3.5	6.4	+81.4
Sugar	53.6	68.3	+27.4
Coffee	10.6	11	+3.9
Protein	102	93	−8.8
Fat	128	137	+7.0
Carbohydrates	408	391	−4.1
Total Calories	3,194	3,167	−0.8

[1] Milk is given as number of milliliters.

STATISTISKE BERETNINGER, 1954, shows the food consumption per consumption unit per day in 452 families of wage earners in 18 cities and 13 industrial centers in 1947–1948 and in 100 similar families in corresponding districts in 1951–1952. Some of the same families were studied in both periods. The most striking changes in the consumption of various foods that took place during the four years are the following: decreased consumption of fish and fish products, bread, potatoes, and butter (but butter has been compensated for by an increase in margarine and fat); increased consumption of cheese, eggs, citrus and dried fruit, and sugar. Differences for other food items are very small. The total calories are nearly the same; carbohydrates decreased 4.1 per cent and protein 8.8 per cent, whereas fat increased 7.0 per cent.

In spite of the fact that the two dietary studies last mentioned are not strictly comparable to those of Galtung Hansen and Strøm, together these studies give an overall picture of the food consumption by families of about the same social and economic status at the following periods: three years before the War, during the War, immediately after the War, two years after the War with some rationing, and six years after the end of the War with no food rationing. Food consumption in the years 1951–1952 may be considered as stabilized on a normal level after the end of rationing, and a comparison between the figures for this period and those for the period 1936–1937 will illustrate to a certain degree the overall changes in the consumption of food which have taken place during a 15-year period with the War in between. There is about equal consumption in the two periods of fat, cheese, and sugar. In 1951–1952, there is less consumption of meat, fish, eggs, bread and coffee, and an increased consumption of milk, flour and potatoes. It is not possible to compare the figures for vegetables and for fruit. In terms of nutrients, the 1951–1952 values are less for total protein and fat than in 1936–1937 and are the same for carbohydrates. The intake of calories also has been reduced.

Conclusion as to the Food Consumption in Norway during

and soon after the War. The diet for pregnant and lactating women and for children 0 to 5 years of age may be considered satisfactory both as to quality and quantity during and soon after the War. For school children older than 8 to 10 years of age, particularly for teenagers, and also for adults, with the exception mentioned above, the calorie value of the available diet was insufficient. This was due mainly to the low fat content, and probably also to low carbohydrate content. The requirements for protein, calcium, phosphorus, iron, vitamins A, B_1, C, and D seem to have been met for all categories of consumers, but particularly for young children and pregnant and lactating women.

Of special relevance to the study of dental caries in children, the most striking changes in the kind and amount of food eaten during the War compared with pre-war and stabilized post-war periods are the following: increased consumption of fish, vegetables, potatoes, cod liver oil, and flour of high extraction; reduced consumption of fat, meat, flour of low extraction, sugar, syrup, and all sugar products.

Since the end of the War, the main changes in diet, and food habits that have been noted in Norway are as follows:

Increased Consumption:

Milk. The consumption of milk has constantly increased from the end of the War and amounted to 671 gms. per person per day in 1951–1952, which is higher than before the War.

Cheese, Meat, Eggs, Fat. The consumption of these foods has constantly increased. Since fall, 1952, margarine has been fortified with vitamins A and D.

Fruits and Vegetables. During the first year after the War, imports of citrus fruit and fresh vegetables were rather small, but there has been a gradual increase so that the total consumption—particularly during the off season for Norway—has increased. The consumption of turnips (rutabaga) and probably of carrots has increased.

Sugar. The war ration for home use of sugar was kept until 1951; but, since the ration for bakeries, confectioneries, and in-

dustry was increased steadily from the end of the War, consumption of sugar was rising constantly. Cakes and pastry as well as jam and various kinds of juices have not been rationed since 1945. As a reaction from the wartime shortage, the consumption of these sugared products has been very high. The rationing of chocolate and candy was kept until September, 1951, but the amount increased from year to year, as is shown in Table 39. It was very common for the children to get the ration for the entire family. The increased sugar consumption has chiefly been through between-meal eating.

White Flour. Soon after the liberation, white flour of 73 per cent extraction was available and it was favored for bread by large groups. The per cent extraction, however, a year later had to be raised to 80 per cent and later again to 85 per cent.

Coffee and Tea. After the liberation coffee and tea were again available.

Decreased Consumption:

Fish. The consumption of fish, including salt herring, has shown the greatest decrease. The reduction was gradual as the consumption of meat increased.

Potatoes. The consumption of potatoes gradually decreased, but it was estimated to be 315 gms. per person per day in 1951–1952.

High Extraction Flour. Whole meal flour for bread has been replaced to some extent by flour of somewhat lower extraction.

Cod Liver Oil. The overall consumption of cod liver oil has decreased, particularly by older children and adults. Pregnant and lactating women as well as babies and preschool children probably have continued after the War to meet the requirements for vitamins A and D by taking cod liver oil or vitamin preparations. Also, the need for school children to take cod liver oil has been strongly stressed by nutrition authorities.

The overall change in diet from pre-war to war period and to post-war period is in the amounts of meat, fat, and refined carbohydrates used. As to the last mentioned, change in the amount of sugar and sugar products ranks first and in second place is the change in use of flour and various products thereof.

The very low consumption during the War of meat, fat, and refined carbohydrates was compensated partly by eating more fish, potatoes, vegetables and whole meal flour.

A Short Review of the Food Consumption and the Dental Condition of Children in Other Countries during and after World War II

DENMARK

Food Consumption during and after World War II. Denmark has a surplus production of all farm products and exports large amounts. During the occupation, the Germans took the surplus and more, and rationing of some foods, particularly of sugar and sugar products was introduced. Table 44 which gives the average daily consumption per person of the main food articles from 1938 to 1948 shows that changes during the war

Table 44. Consumption of various foods in Denmark, 1938–1948, according to Statistiske Efterretninger, 1949.

Kind of Food	Grams Consumed per Person per Day										
	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948
Flour and Cereals	267	268	290	290	284	293	299	301	295	291	295
Meat	181	180	194	167	164	162	160	176	190	187	168
Fish	21	22	20	21	27	33	30	34	33	44	49
Fat											
Butter	23	24	39	49	49	48	48	46	39	25	10
Margarine	59	61	26	8	—	—	—	—	3	16	30
Pork Fat	2	3	7	6	4	6	7	6	6	.2	.2
Total Pure Fat	68	72	59	52	44	46	46	43	41	36	34
Whole Milk, Including Cream	465	463	397	372	410	438	490	542	526	487	452
Cheese	15	14	14	13	15	21	22	25	22	19	23
Eggs	21	21	24	18	21	23	29	29	29	26	29
Potatoes	315	315	328	342	356	369	369	369	369	328	342
Vegetables	250	273	282	283	273	294	287	264	253	231	241
Fruit	80	100	71	74	70	82	89	77	116	99	143
Sugar	138	152	120	118	120	92	90	74	88	89	91
Chocolate and Other Sugar Products	18	19	15	12	12	8	10	10	17	16	15
Calories—Number	3,395[a]		3,270	3,130	3,050	3,115	3,170	3,145	3,200	3,095	3,065
Calorie Index: 1935–1939 Average = 100	100		96	92	90	92	93	93	94	91	90

[a] Average number per person per day 1935–1939.

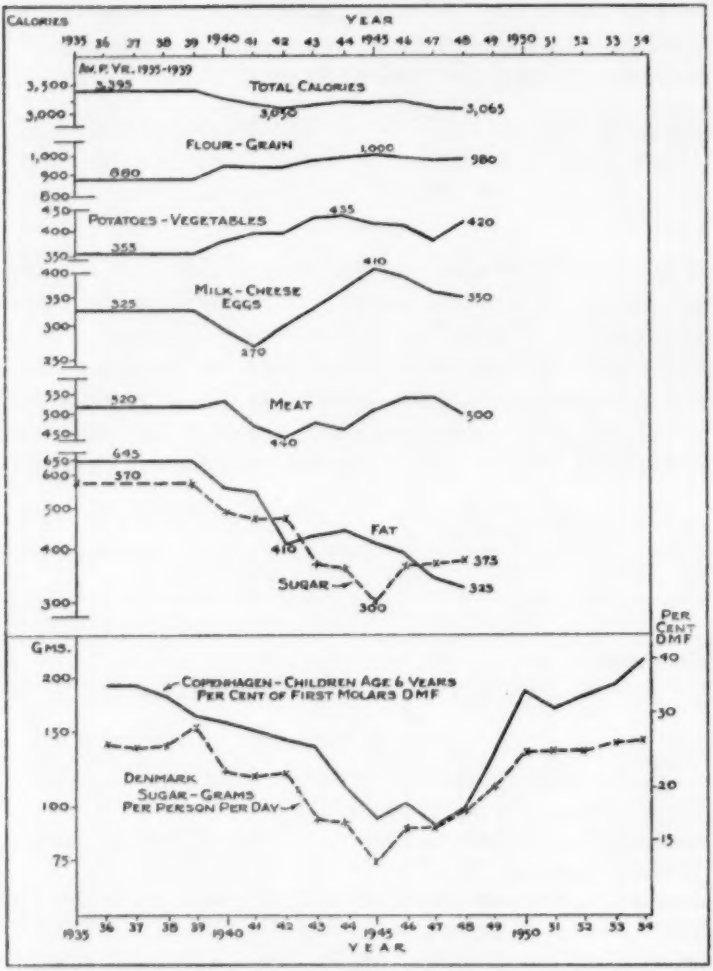


Fig. 43. Calories per person per day from the principal food groups, in Denmark, based on average annual consumption 1935–1939 and annual consumption, 1940–1948; also, the percentage of permanent first molars affected with caries for six-year old children in Copenhagen, and number of grams of sugar per person per day used in Denmark, in 1936–1954. *Scale for number of calories is logarithmic.*

years were rather slight, except for sugar, sugar products, and margarine. The changes are even better demonstrated in Fig-

ure 43 which shows total calories and also the calories from the six main food groups for the period 1935–1939, and each year from 1940 through 1948. The average number of calories per person from all foods dropped from the very high level of 3,400 per day before the War to 3,050 in 1942, but increased somewhat up to 1946 and later decreased to the 1942 level. Calories from flour and cereals and from vegetables, including potatoes and fruit, increased during the War. In spite of a slight drop after the War, calories obtained from both of these groups were higher than before the War. Calories from milk, cheese, and eggs went down until 1941 but increased considerably during the later war years. After the War, calories from these foods decreased somewhat but are higher than the pre-war level.

The meat curve, including fish, shows an abrupt drop to 1942 and slowly returned to the original level in 1946 and 1947. The fat curve, including butter, margarine, and pork fat, shows a nearly constant drop from 645 calories as the pre-war value to 325 in 1948. More than half of the decrease is during the first two years. The sugar curve, including chocolate and other sugar products, goes continuously down from the pre-war value of 570 calories to 300 in 1945 and rises to 375 in 1948.

The big decrease in sugar and fat calories has been partly compensated for by an increase in flour, vegetables, and milk.

Fredericia (1947) in his report on nutritional investigations in Denmark during the War stated that the amount of food was sufficient in all groups. One per cent calcium phosphate was added to the wheat flour and oatmeal.

As to the health of the population, he states that there was no change from before the War. Even the school children were in good condition. There was, however, a small but significant decrease in hemoglobin and also a small decrease in dark-adaptation.

The Condition of the Teeth of Children. By courtesy of Krohn, the director of the school dental clinics in Copenhagen, the per cent of children who were caries-free and per cent of permanent first molars with caries for 6 year-old children from

1936–1954 are tabulated in Table 45 together with the total daily consumption of sugar and the average daily intake of chocolate and other sugar products per person. The per cent caries-free children increased very little from 1936 to 1939, but from then on there was a constant and appreciable increase through 1948. The figure in 1939 was 2.7 per cent caries-free children, and in 1948, it was 13.8. After 1948 a sudden big decrease took place and the per cent dropped to 6.1 in 1953 and 1954. Corresponding to these changes the percentage of DMF first molars shows a decrease followed by an increase. The decrease in DMF first molars noticed before the War was accelerated through 1945, leveled off through 1948 and then increased very sharply. The 1939 per cent was 29.3, the 1945 per cent was 16.8. The increase in percentage after 1948 is very

Table 45. The dental condition in 6 year-old children in Copenhagen and the average consumption of sugar in Denmark, 1936–1954.

Year	Per Cent of Children Caries Free	Per Cent of Permanent 1st Molars with Caries	Total Sugar in Gms. per Person per Day	Sugar for Chocolate and Other Sugar Products Gms. per Person per Day
1936	2.3	34.4	141	18
1937	2.2	34.6	137	17
1938	2.8	32.6	139	18
1939	2.7	29.3	153	18
1940	3.5	28.3	121	15
1941	4.1	26.8	118	13
1942	4.6	25.8	120	13
1943	5.4	24.7	94	9
1944	6.3	19.8	92	11
1945	9.1	16.8	74	10
1946	10.3	18.3	89	18
1947	13.0	16.3	90	16
1948	13.8	17.8	98	16
1949	12.0	23.7	110	18
1950	8.5	33.3	133	19
1951	7.3	30.5	135	14
1952	7.0	32.3	134	15
1953	6.1	34.6	140	15
1954	6.1	39.8	142	15

Total number of children examined: 190,000.

rapid and for 1954 the DMF rate surpassed the pre-war per cents. (The children in 1954 however, are a few months older than in previous years.)

As will be seen in Table 45, the amount of sugar consumed also underwent great changes during the same period. From 137 to 153 gms. consumed daily before the War, the amount in 1945 was reduced to 74 gms. and afterwards increased to 142 gms. in 1954. The relationship between the sugar consumption and the caries frequency is illustrated in Figure 44. There is a rather close parallelism between the sugar curve and the curve for DMF first molars. The only discrepancy is the high peak of the sugar curve in 1939 and the lag in the rise of the caries curve in 1946 and 1947. This lag will be discussed later.

In Figure 43 it is also seen that the curve for the consumption of chocolate and other sugar products follows the caries curve.

FINLAND

Food Consumption during and after World War II. As Finland had gone through the War with Russia during the winter 1938–1939, the food conditions were probably not as good in Finland as in the other Scandinavian countries when the Second World War started. Table 46 shows the rations of the chief types of food in Finland during the years 1941–1945 according to Tikka (1947). In order to evaluate the extent of changes from the pre-war values, the average figures for consumption in the years 1934 to 1938 are shown, and have been taken from international data on food consumption in STATISTICAL YEARBOOK, 1949.

As to the farm products, the self-supporting population had a ration of flour, milk, and meat comparing fairly well to amounts used before the War, but the amount of fat and particularly of sugar was very much reduced. For the remainder of the population, all the rations, except milk for children, were much lower than usual.

According to Tikka, the farm population had a fairly good

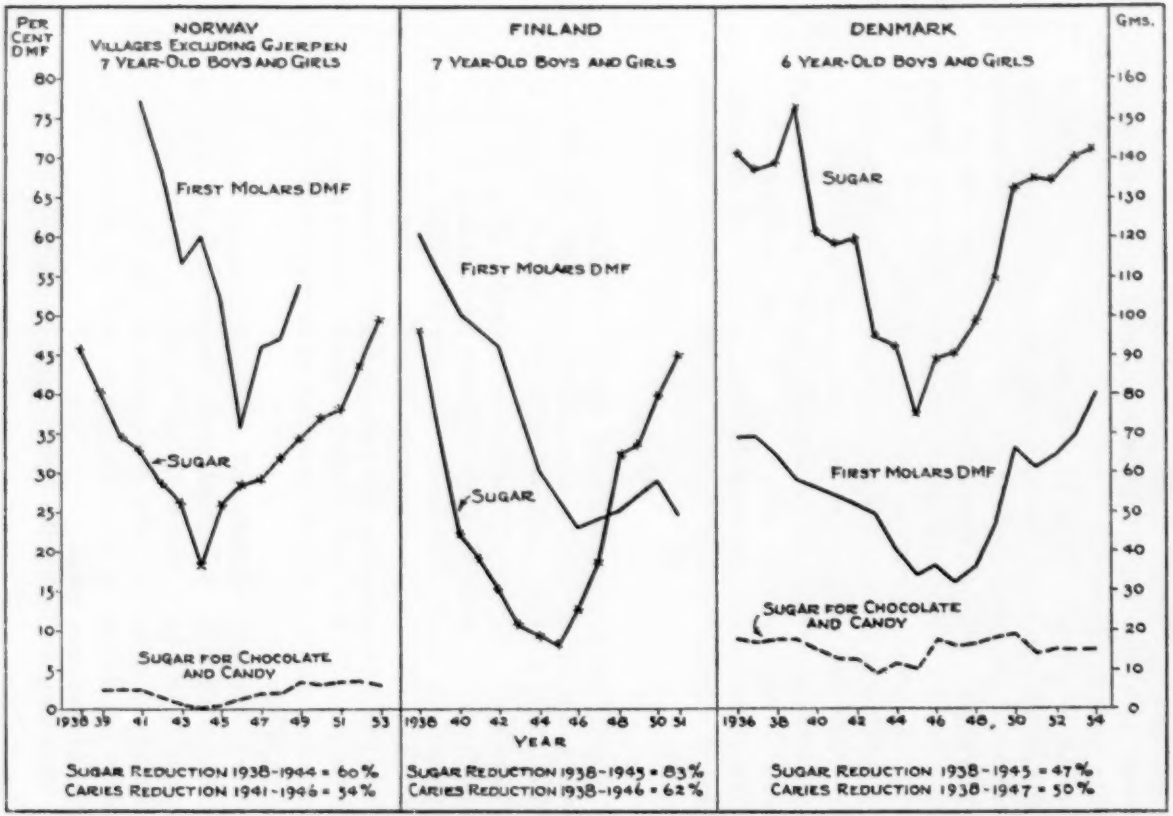


Fig. 44. Sugar consumption in Norway, Finland, and Denmark (grams per person per day) in pre-war, war and post-war years and DMF rates for permanent first molars in 7 year-old children in Norway and Finland, and 6 year-old children in Copenhagen.

amount of farm products during the whole war but industrial workers, officials, and intellectuals suffered severely. Animal proteins, such as meat, fish, and dairy products, formed an alarmingly small part of the diet, he writes. Loss of weight and edema were relatively common and rickets developed in as much as 80–90 per cent of the children in certain areas. As production of milk decreased considerably, the whole ration of milk could not be attained. This was true even for children. The intake of vitamins A and C was low.

Condition of the Teeth of Children. Many studies have been published on the decrease of dental caries in children during the War: Wilska 1946, Ekman 1948, and Calonius 1953. From the

Table 46. Rations of the chief types of food in Finland during the years 1941–1945.[1]

Type of Food and Consumption 1934–1938[2]	Category of Consumers	Rations in Grams per Person per Day				
		1941	1942	1943	1944	1945
Cereals	Children 0– 3 Years	197	159	148	148	150
351 gms.	4– 9 Years	197	197	197	197	199
	10–12 Years	218	210	240	247	240
	13–16 Years	218	259	290	296	281
	Persons Doing Intellectual or Light Work	218	210	240	247	240
	Self-Supporting Families: Adults	562 460	493	477	493	455
	Children 0–7 Years	345	370	312	329	307
Fats	Children 0–17 Years	30	19	23	25	26
41 gms.	Persons Doing Intellectual or Light Work	25	13	16	16	18
Milk	Children 0– 1 Years	1,000	1,000	1,000	908	899
712 gms.	1– 2 Years	1,000	1,000	1,000	892	899
	2–17 Years	600	600	600	600	600
	Adults	280	200	267	283	225
	Self-Supporting Families: Children 0–17 Years	1,000	1,000	1,000	1,000	1,000
Meat and Meat Products	Children and Persons Doing Intellectual or Light Work	39	18	18	50	21
90 gms.	Self-Supporting Families	82	82	70	70	70
Sugar and Syrup	Basic Ration	38	32	21	18	16
79 gms.	Holders of Tobacco Card	—	30	12	10	8
	Children 0– 6 Months	50	50	50	50	50
	6–12 Months	25	25	25	25	25

[1] Calculated from Tikka (1947).
[2] Average grams per person per day for total population, taken from International Statistical Yearbook, 1949.

last-mentioned publication, Table 47 has been prepared for the period from 1936 to 1951. In the same Table the daily consumption of sugar also is shown. In Figure 44, the percentages of DMF first molars in 7 year-old children (boys plus girls) are plotted together with the averages for the daily consumption of sugar in each year. Here, too, these two curves are nearly parallel from 1938 to 1945–1946 and then show a very great decline. The maximum reduction in sugar is 83 per cent and that in caries 64 per cent. As the figures for DMF are given only for every other year, it is not possible to fix the lowest part of the curve according to yearly examinations. From the available figures the DMF curve turns upwards after 1946 whereas the sugar curve starts rising from 1945. The rise in the sugar curve for Finland is much steeper than the rise in the caries curve, which differs from the experience reported for Denmark.

Sugar consumption in Finland is lower for every year than that in Denmark. The height of the caries curves for the two countries cannot be compared as the curve for Denmark represents 6 year-old children and that for Finland 7 year-old children. Because of this difference in age it is understandable

Table 47. Per cent of children with permanent first molars erupted and per cent of molars DMF in 7 year-old Finnish children in the years 1936–1951, (calculated from Calonius) and sugar consumption in grams per person per day.

Year	Number of Children Examined		Per Cent of Children with Erupted Molars		Per Cent of Erupted First Molars DMF			Sugar in Grams
	Boys	Girls	Boys	Girls	Boys	Girls	Boys and Girls Combined	
1936	141	147	91.7	96.9	54.2	60.4	57.3	77
1938	100	100	94.3	96.3	58.9	62.3	60.6	96
1940	200	200	91.0	96.9	44.8	55.2	50.0	44
1942	200	200	93.5	97.5	42.5	49.9	46.2	30
1944	200	200	92.4	95.5	25.3	34.3	29.8	18
1946	100	100	94.3	94.8	24.1	21.4	22.8	25
1948	183	184	91.8	97.7	21.4	28.8	25.1	65
1950	102	102	94.4	97.5	24.9	34.4	29.7	79
1951	105	108	89.5	94.7	19.2	29.8	24.5	90

that the caries rates for Finland are higher than those for Denmark.

The total food situation was worse in Finland than in Denmark, Sweden, and Norway. Also, the reduction in sugar was greatest in Finland and so was the reduction in dental caries.

SWEDEN

Food Consumption in Sweden during and after World War II. In spite of the fact that Sweden was a neutral country during the Second World War, the most important foods, except for milk and potatoes, were rationed during the War. The severity of rationing, however, could not be compared with that in Norway and Finland. Table 48 calculated from Sandberg (1946) presents the daily intake in grams per consumption unit in the first quarter of the years 1940–1945. The figures for 1940 may be taken as representing the average normal intake. Based on the 1940 values, there was some decrease in the consumption of cheese, fat, meat and pork, and sugar mainly in 1941, 1942, 1943, and 1944. Consumption of milk, potatoes, and vegetables increased very much and the intake of fish, flour, and cereals also shows some increase. The increased use of fish nearly offset the reduction in meat. The consumption of fat and sugar both decreased about 15 per cent.

Table 48. Food intake in grams per day per consumption unit in the first quarter of the years 1940–1945 in Sweden.[1]

Foods	1940	1941	1942	1943	1944	1945	Per Cent Change 1940–1944
Milk	649	667	755	874	861	842	+32.6
Cheese	21	18	7	10	15	15	−27.0
Fat	65	51	53	54	55	62	−15.1
Meat and Pork	135	128	120	75	116	102	−14.1
Fish	51	40	47	76	58	61	+12.7
Flour and Cereals	308	321	306	329	320	335	+ 3.9
Potatoes	318	320	400	450	431	396	+35.4
Vegetables	65	75	88	99	79	71	+21.6
Sugar, Syrup, Sweets	101	93	91	84	86	83	−14.6

[1] Calculated from Sandberg (1946).

Data taken from Abramson (1947) in Table 49 giving estimates of various nutrients during the same years expressed as percentages of the supply in the first quarter of 1940, are based on twenty-two study periods in 500 households in different towns. As will be seen, the 1940 values were maintained and even surpassed for most of the nutrients. An increase is particularly true for the valuable nutrients such as calcium, phosphorus, iron, and ascorbic acid. The only nutrient showing a real decrease in most of the years was fat.

Extra rations were given to pregnant and lactating women, to heavy workers, and certain groups of children and young people.

Abramson states that the food situation on the whole was satisfactory. Only the supply of vitamin A was more or less regularly below the desired level. He concludes that no injurious effect on the state of health of the population was observed.

Table 49. Calories and nutrient values for foods consumed in Sweden during the war years, 1940–1945, expressed as a percentage of the supply in the first quarter of 1940.

Year	Calories	Protein	Fat	Carbohydrate	Calcium	Phosphorus	Iron	Vitamin A	Vitamin B_1	Ascorbic Acid
1940										
1st Quarter	100	100	100	100	100	100	100	100	100	100
3rd Quarter	99	101			104	104	104	148	105	112
1941										
1st Quarter	98	103	88	107	105	106	109	97	106	99
3rd Quarter	94	97	80	100	102	122	107	135	105	107
1942										
1st Quarter	96	96	80	105	100	99	103	81	118	95
3rd Quarter	95	97	76	106	113	104	94	127	106	130
1943										
1st Quarter	97	102	75	110	114	103	100	102	103	105
3rd Quarter	96	103	86	110	155	109	109	92	113	134
1944										
1st Quarter	101	105	88	107	116	122	111	103	112	107
3rd Quarter	99	101	94	101	115	105	103	108	108	105
1945										
1st Quarter	99	104	89	105	112	103	106	87	105	88

The death rate, which was decreased before the War, continued to decrease and in 1942 was the lowest recorded in Sweden. A striking reduction occurred in the number of deaths from diabetes.

Table 50. Per cent of permanent teeth decayed, and not filled, in 7 year-old boys and girls combined, examined in the Swedish public dental clinics; and the average consumption of sugar per person per day.

Year	Per Cent of Teeth with Decay	Consumption of Sugar in Grams per Person
1939	—	149
1940	—	123
1941	29.1	111
1942	27.5	122
1943	24.3	114
1944	24.9	111
1945	24.1	110
1946	24.4	108
1947	25.3	106
1948	28.2	117
1949	—	125
1950	29.3	136
1951	—	123
1952	—	123
1953	29.2	119
1954	29.0	123

Condition of the Teeth of Children. A decrease in caries frequency in school children has been reported by several investigators, among others Sandberg (1946), Maunsbach, Olinder, and Ander (1947). Table 50, compiled from reports from Kungliga Medicinal Styrelsen (1956) gives the per cent of permanent teeth with open decay and not filled in 7 year-old children examined in the public dental clinics. Consequently the figures do not express the total caries picture. The authors state, however, that very few permanent teeth have been treated before entering the clinics so that the difference should be nearly negligible. In the same Table, figures for the daily consumption of sugar, including syrup, per person have been added. The figures for caries and for sugar have been plotted in Fig. 45. The decrease in percentages of carious teeth is rather small compared with that for a corresponding age group in Norway. The figures for the Norwegian group comprise the total caries picture, that is, DMF, and not only teeth with open decay as in the Swedish figures. The maximum decrease for the Swedish group is about 17 per cent compared with about 53 per cent for the Norwegian group. The maximum reduction

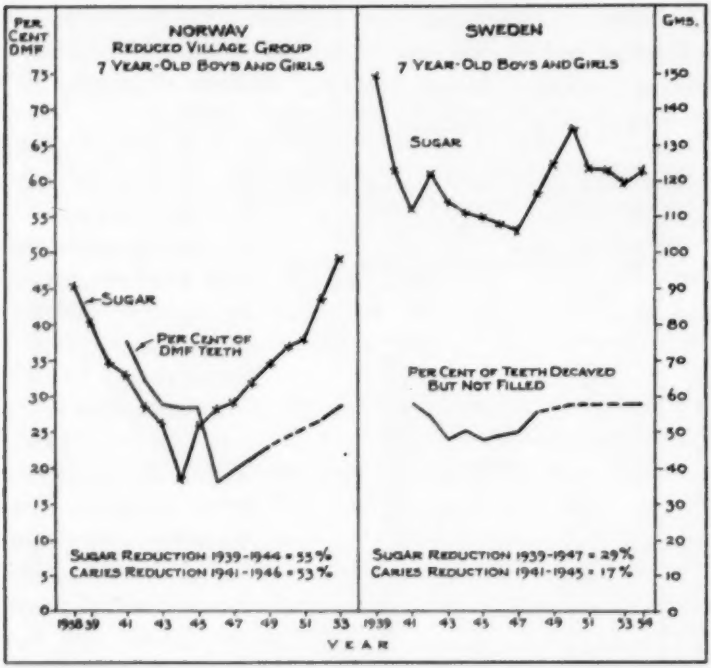


Fig. 45. Sugar consumption in Norway and Sweden (grams per person per day) in pre-war, war and post-war years and per cent of erupted permanent teeth DMF for 7 year-old children in Norway, and per cent of teeth decayed but not filled for 7 year-old children in Sweden.

in sugar consumption after 1939 is 29 per cent in Sweden and 55 per cent in Norway. In spite of the somewhat uneven sugar curve for Sweden there is a parallelism between the sugar curve and the caries curve.

The consumption of essential nutrients and also of total calories during the War was without doubt better in Sweden than in Denmark, Finland, and Norway. The reduction in sugar and sugar products was the least in Sweden and so was the reduction in the amount of caries in children.

SWITZERLAND

The Condition of the Teeth of Children during World War II. Very extensive studies on the influence of war-time conditions

on teeth of children were made in Switzerland by Adolph Roos (1950). The population studied was children in the first school grade, 6 to 7 years old, in the school dental clinic of Basel where Roos himself each year from 1934 to 1947 examined from 1,400 to 1,700 boys and girls. In his report every other year has been considered—comprising 6,456 boys and 6,111 girls. At each examination the following items were recorded: the number of deciduous and permanent teeth present, the number of deciduous and permanent teeth without caries, the number of carious teeth, and the number of filled teeth. The data have been analyzed in various ways, but only the most important findings will be summarized here.

As shown in Table 51, the per cent of children with caries-free deciduous teeth increased four to five times from 1940 to 1947. The same is true for the permanent teeth only. The per cent of children totally caries-free increased even more, boys about 6 times and girls about 13 times. Corresponding to this, the percentage of teeth found to be carious decreased during the same period, from 34 to 22 per cent for boys and from 37.5 to 24.0 per cent for girls. It will be seen from the Table

Table 51. Dental status of 6 and 7 year-old children in the school dental clinic of Basel, Switzerland. (Calculated from Roos.)

	1940	1942	1945	1947	1949	1952
Per Cent of Boys with Caries-Free Deciduous Teeth	5.5	7.0	16.0	20.0	14.5	9.5
Per Cent of Girls with Caries-Free Deciduous Teeth	3.5	5.5	11.0	18.5	12.0	9.0
Per Cent of Boys with Caries-Free Permanent Teeth	11.0	14.0	41.0	45.0	36.0	25.0
Per Cent of Girls with Caries-Free Permanent Teeth	8.0	11.0	32.0	39.0	29.0	24.0
Per Cent of Boys with Caries-Free Deciduous and Permanent Teeth	2.5	3.5	12.5	16.0		
Per Cent of Girls with Caries-Free Deciduous and Permanent Teeth	1.0	2.5	7.5	13.5		
Per Cent of Deciduous and Permanent Teeth with Caries—Boys	34.0	32.0	26.0	22.0	27.0	32.0
Per Cent of Deciduous and Permanent Teeth with Caries—Girls	37.5	33.0	27.0	24.0	28.0	33.0

that the changes are gradual and constant from year to year.

Some improvement of the dental condition had taken place from 1934 to 1940, but the magnitude of this could not be compared with that during the period after 1940.

Comparing the status for 1934 with that for 1947, Roos gives the following figures: The total number of carious teeth per child decreased from 8.78 to 5.11, a reduction of 42 per cent. The relation between caries-free and caries-affected deciduous teeth in 1934 was 7.5 to 6.0 with practically no change up to 1943, but in 1947 the ratio was 10.9 to 4.0. For the permanent teeth, the corresponding figures were 5.2 to 2.3 in 1934 with a small improvement during the rest of the pre-war period and, in 1942, 7.8 to 1.9. The more rapid improvement of the condition of the permanent teeth during the War is ascribed by Roos to the fact that the newly erupted teeth are more easily influenced by changes in environment than are the old ones.

Roos (1956) reports further studies of corresponding age groups which show a rapid change toward pre-war conditions. (*See* Table 51.) The per cent of children with caries-free teeth decreased and the percentage of carious teeth increased in 1949 and 1952 as compared with 1947.

The changes in dental condition of the Swiss children correspond very well with those of the Scandinavian children.

As to the total number of teeth present per child during the first period, that is to 1947, Roos found no change from 1934 to the beginning of the War; but during the War and to 1947 a definite increase took place in both sexes. This increase in the number of teeth per child means, he writes, that "the evolution of the second dentition has been more rapid." This "rapid evolution" of the second dentition, he writes, may be caused partly by the coarser foods in the special war diet and the associated increase in chewing and partly by nutritional factors in the diet. However, later in his report several tables demonstrate that from 1943 to 1947 there are not more permanent teeth present per child than before the War. Here, he also mentions the longer persistence of the temporary teeth.

These last findings are in accord with ours from Norway, *see* Part 1 of this report (Toverud 1956).

Roos also shows very clearly that the boys have more temporary teeth present than the girls and corresponding to this, fewer permanent teeth present than the girls. This is also in agreement with our findings from Norway.

The War Diet in Switzerland. Roos (1950) has given fairly detailed descriptions of the diet and nutritional condition during the War. Except for potatoes, vegetables, and fruit, all the main foods were rationed. The consumption of *potatoes* increased from about 200 gms. per person per day before the War to 400 gms. during the War; the consumption of *vegetables* increased from about 190 gms. to 400 gms., and the consumption of *fruit* increased from about 170 gms. to about 300 gms. As to the rationed foods, the following information is of interest:

Bread. Before the War, bread was made of flour of 70 per cent extraction. At the beginning of the War, the extraction per cent was raised to 80 and later to 90 and 96 per cent.

Milk. The ration of milk was from 600 to 700 ml. per day, the same average consumption as before the War. The milk producers were allowed one liter.

Cheese. Before the War, consumption averaged around 22 gms. and this was kept up during the war period.

Meat. The consumption of meat before the War was 142 gms. per person and during most of the war period it was reduced to 82 gms.

Fat. The average consumption of 100 gms. of fat before the War was reduced to about 40 to 60 gms.

Eggs were scarce.

Sugar. The average consumption of sugar in the years 1936 to 1938 was 82 gms. per day. In 1940 it was 93 gms. per day and in 1941 63 gms. per day. For the rest of the war years, consumption varied between 41 and 50 gms. per day.

Pastry. Before the War the average consumption was 24 gms. per day. From 1941 to 1945 the ration varies between 10–15 gms. per day.

Rice. The ration of rice was about 1 kg. during the War compared with 5 kg. per year before the War.

Compared with the pre-war period the consumption during the War of various food groups, on the average, was:

Milk and Milk Products: 90–100 per cent.
Bread Flour: 80 per cent.
Pastry: 50 per cent.
Meat, Butter, Fat, Oil: 60–70 per cent.
Sugar: less than 50 per cent.
Rice: less than 30 per cent.
Peas and Beans: 150 per cent.

The diet was more of a lacto-vegetable type during the War than before the War.

Among the changes of diet from pre-war to wartime of particular interest as to the decrease in dental caries, Roos stresses the change from low-extraction flour to high-extraction flour and the reduction in sugar consumption. He states that it was a common experience among the school dentists to find that the teeth of the children were much cleaner after they started with the war bread. After the War, the teeth again showed more plaques when they returned to the bread made from the low-extraction flour.

GREAT BRITAIN

May and Helen Mellanby (1948) give very interesting in-

Table 52. Dental condition in 5 year-old children attending London County Council Schools 1929–1951, according to Mellanby and Mellanby, 1950 and 1954.

Year of Examination	Number of Children Examined	Per Cent of Children Caries Free	Per Cent of Carious Teeth	Extent of M-Hypoplasia (A.H.F.)
1929	1,293	4.7[a]	—	—
1943	1,870	14.9	30.1	1.04
1945	691	24.2	26.5	0.91
1947	1,590	28.1	20.3	0.67
1949	692	14.9	26.7	0.88
1951	1,395	—	27.5	0.77

[a] This includes "almost caries free." The totally caries free were negligible.

formation on dental caries in 5 year-old London school children from 1929 to 1947. Table 52 shows that the percentage of caries-free children increased from 4.7 in 1929 to 24.2 in 1943, to 28.1 in 1945 and to 37.5 in 1947. The great increase in percentage of caries-free children from 1929 to 1943 is ascribed by the authors to the general improvement in the nutritional condition of pregnant and lactating mothers and of children.

With respect to nutritional changes related to the improved dental condition during wartime and post-wartime, the authors give the following information. From July, 1940, all expectant mothers could claim a milk priority of 1 pint a day. After the child was born, 2 pints a day were allotted for mother and child for the first year. From the age of 1–5 years the child was allocated 1 pint a day. Some extra milk could be obtained during school days. From December, 1941, cod liver oil was made available at a reduced rate through welfare centers, clinics, and food offices to children from 6 months to 2 years and from February, 1942, provision was extended to all children up to the age of 5 years. Expectant mothers were eligible for cod liver oil from December, 1942, and from April, 1943, vitamin A and D tablets were instituted as an alternative. From 1940 all margarine was fortified with vitamins A and D. Calcium carbonate in the amount of 200 gms. per 127 kilo of flour was added from 1942 onwards. In 1946, this amount was doubled. The addition of calcium was necessary because the wartime flour of 85 per cent extraction or higher as against the pre-war 70–73 per cent contained more phytate, and the calcium added to the flour should be sufficient to neutralize the harmful anti-calcifying properties of the phytate. More eggs also were available to mothers and young children than to non-priority classes.

The authors write: "It appears then from the foregoing account of recent diet changes that an important reason in the more rapid improvement in the dental condition of children between 1945 and 1947 as compared with the preceding years is clear-cut. For the first time in the course of these surveys all expectant and nursing mothers and all children up to the age

of 5 years have been in a position to obtain increased quantities of calcium and vitamin D via established milk, cod liver oil, and egg priorities and they have benefited further by other government measures outlined above; so that throughout the whole ante-natal and post-natal life of the latest group of children examined who were born between November, 1941, and October, 1942, the diet available has been of consistently better calcifying qualities than that of the subjects of the earlier surveys. The pre-eruptive diet has produced better calcified teeth than were formerly observed and the post-eruptive diet has tended still further to increase the already higher resistance of these teeth to caries."

The authors do not mention that at the same time the sugar consumption also changed. From 1941 to 1947, the amount of sugar per person decreased between 65–77 per cent from the pre-war level. It is the view of the present writer that this great reduction in the consumption of sugar has without doubt also played a role in the improvement of the dental condition.

The same authors have continued their studies in 1949 and 1951 (publications 1950 and 1954). Table 52 shows that the percentage of caries-free children in 1949 has dropped to half of that in 1947 and the percentage of teeth with caries has increased from 20.3 in 1947 to 26.7 in 1949 and to 27.5 in 1951. This change in the caries picture corresponds well to that reported from Scandinavia.

No comments are given in reporting the results of the 1949 study. In the publication of 1954, however, the causes for the deteriorated dental condition are discussed. "It seems probable," the authors write, "that this may be due, in part at least, to changes in the diet, some of which would tend to increase and others to decrease the liability to dental caries, the former are balancing the latter." The authors further mention that the availability of protective foods may not have changed but to what degree they have been taken by mothers and children during the latest years cannot be stated. The consumption of oatmeal and other cereals and cereal products have probably

increased after 1948 and that means a greater demand for calcium and vitamin D. Sugar and sweets (including chocolate) were still rationed at the time of the latest investigation and although the allocations to individuals were on a slightly higher level after 1948 than before, the authors do not consider this to have much direct influence on the initiation and spread of caries, or an indirect one by limiting the consumption of other foods.

As is seen from Table 52, the extent of M-hypoplasia was also lowest in 1947 and had increased in 1949 but again decreased in 1951. In 1951, 42.3 per cent of the teeth were non-hypoplastic as against 32.0 per cent in 1949. In spite of the M-hypoplasia being of only slight degree, according to the authors, this discrepancy in the authors' concept of close relationship between dental structure and caries is worthy of consideration. The present writer wants to point to his comments on the decrease in caries rate up to 1947.

The good nutritional condition of mothers and children in England during the War, reported by Mellanby and Mellanby is in agreement with the report of the chief medical officer of health in 1944. This reads "In the fifth year of the War the vital statistics for mothers and children are the best that we have ever had and that the death rate for children up to 10 years of age was the lowest on record. Better nutrition had made a most important contribution." (Quoted from Oliver 1946.)

Channel Islands. From the Channel Islands, which were occupied by the Germans, Bransby and Knowles report in 1949 very interesting studies on the diet and dental condition in children. In 1945, the caries rate in children was remarkably low, particularly in children 5 years or younger. No data were available for prewar years so the amount of reduction could not be stated. Similar data for 1947 showed a very great increase in the caries rate. In 3 to 5 year-old children the increase was from about 4 *dmf* deciduous teeth per child in 1945 to 7–8 *dmf* teeth in 1947. Nutritionally, the diet was rather poor dur-

ing the occupation. The sugar ration was particularly low, about 30 gms. per day for children. The main changes in the diet from 1945 to 1947 were as follows: An increase in consumption of meat, bacon, fish, eggs, cheese, vitaminized fats (butter and margarine), and canned milk. A slight decrease in fresh milk. An increased consumption of fruit. A reduction in the amount of roughage in the diet. More frequent and greater consumption of puddings and prepared dishes. A considerable increase in the consumption of sugar, jam, and confectionery. Probably, there was a reduced rate of extraction of flour and a lower fortification of bread with calcium.

A small group of children from the Channel Islands was evacuated to England before the German occupation. These children returned to the Islands soon after the liberation and were examined together with the other children both in 1945 and 1947. The evacuated children had a much higher caries rate in 1945 than the children who had stayed at the Islands during the occupation, and they did not show the same increase in caries rate from 1945 to 1947. The diet in the Channel Islands after the liberation approximated that in the United Kingdom. The diet of the evacuated children, therefore, had not changed in the same way as that of the children who had remained on the Islands.

HUNGARY

From Hungary, Adler, 1956, has reported that the caries rate in permanent first molars was lowest in those which erupted during the war years with the most restricted diet. He ascribes this to environmental conditions in the mouth especially favorable for the first post-eruptive maturation to take place without any disturbing factors. On the other hand, he writes, there is a possibility that the teeth of children born during that time will be affected by the poor nutrition.

THE NETHERLANDS

From the report on food supply and nutrition during and immediately after the War by Dols and van Arcken, 1946, we

learn that most of the food items were rationed with the exception of vegetables, fruit, and fish, but these "furnished negligible amounts to the food values under discussion." No detailed information on the food rations are given, but it is stated that the consumption of carbohydrates increased, that of fat and protein decreased. Milk for very young children varied from 5.25 liters to 7 liters per week and these children were given vitamins D and C. Expectant and nursing mothers also had vitamin C tablets.

The very extensive publication MALNUTRITION AND STARVATION IN WESTERN NETHERLANDS (1948) indicates clearly that children 0–3 years of age had a surplus of protein, fat, and carbohydrates in the ration, whereas children 4–14 years received an insufficient amount of all of these items. Rations for adults were the most deficient.

As to the general health of the population, the following statements are made: From 1940 to October, 1944, the inhabitants suffered relatively mildly from lack of food. After October, 1944, however, the situation was very bad, resulting in great deterioration in health.

This report on Western Netherlands gives some findings from dental examinations in a group of 452 individuals in 1945 and 1941. In children 6 to 13 years of age, a small but not significant reduction in the number of carious teeth was found for 1945 as compared with 1941. No comment on the cause of the reduction is given.

Cady published the result of a dental study in 1946 on about 500 Dutch children who were evacuated to England soon after the first invasion of the Netherlands. Comparison of the caries rate in these children with children from New Jersey showed the caries rate to be much lower in the evacuated children than in the American children.

Steijling-Lindeboom and collaborators (1948) reported on the time of eruption and the caries rate in three groups of children living in institutions and in private homes during the War. One group was studied only in 1941 and 1942; one group in

1941, 1942 and 1943; and a very small group in 1941, 1942 and 1945. For the younger children in the last group, a small decrease in the caries rate is shown and this has been related to a delayed eruption of the teeth and the associated shorter post-eruptive age of the teeth. For the other two groups, rates for the different years are so variable that no conclusion can be drawn.

BELGIUM

Watry (1949) reports on dental examinations of children in the Eastman Dental Institute of Brussels. In children 10–12 years of age the per cent of caries-free first permanent molars was as follows: Before the War 9; 11 in 1941; 16 in 1942; 20 in 1943; 20 in 1944; 22.5 in 1945; 16 in 1946; and 10 in 1947. The percentage of caries-free teeth increased steadily from 1941 to a maximum in 1945, and then decreased rapidly in 1946 and 1947. Watry states that caries have become more and more frequent since 1946–1947. This seems to confirm, he writes, the opinion of various observers in this particular field that the decrease in dental caries is due to the disappearance of certain foods which affect the condition in the mouth, that is, sugars, fats, and so on. No detailed information is given on the food situation.

FRANCE

Dechaume (1946) published the results of studies on the dental condition of children in Paris. In January, 1942, 13 per cent were caries free. In the same month in 1943, the percentage was 27; in 1944 it was 37.6; and in 1945, 44.8. In the first year, 1,000 children were examined and in the subsequent years 500 each year. As the cause of this reduction in the amount of dental caries, Dechaume stresses particularly changes in sugar consumption, which he considers to have not only local effects in the mouth but also systemic effects.

GERMANY

Various reports have been published on the changes in caries rates for German children during the years before, during and after World War II. Kantorowicz (1953) reports on an overall

decrease in the number of carious permanent teeth per child in 14 year-old children from 6.82 to 2.30 in a period from 1918 to 1951. An adjusted caries rate for permanent teeth of 6 year-old children shows a sharp decrease from 1936 but the decrease is much greater from 1941 to 1946. From 1946 to 1950 the curve turns upward with about the same slope but does not reach the value for 1941. From 1950 to 1951 the curve again drops suddenly. The figures for the 6 year-old children are from DEUTSCHE BUNDESSTATISTIK, 1951.

Pazurek's study (1952) on 7 year-old children in Berlin-Tiergarten, however, gives a somewhat different picture from 1948 through 1952. As Table 53 shows, the per cent of children with caries free permanent teeth increases from 1948 through 1950 and then decreases in 1951 and 1952 to a much lower percentage than in 1948. Corresponding to this, the number of caries affected permanent teeth is very low in 1948, 1949, and 1950, but increases threefold in 1951 and more than nine times in 1952 for children born in 1945. The last value is even much higher than those of 1935 and 1937.

It is difficult to understand the discrepancy in the trend of the caries rate during the period 1948 through 1951 in the last two reports.

Kantorowicz's explanation of the cause of changes in caries rate will be discussed later.

H. Mellanby (1949) reports on dental studies of 5 year-old

Table 53. Dental condition in 7 year-old children in Berlin-Tiergarten. (*From* Pazurek, 1952.)

Year of Birth	Year of Examination	Number of Children Examined	Per Cent of Children with No Caries	Carious Permanent Teeth Number per 100 Children
1928	1935	500		29.8
1930	1937	500		28.8
1941	1948	500	34.6	5.0
1942	1949	300	42.3	3.7
1943	1950	1,000	49.5	5.1
1944	1951	1,000	42.8	14.0
1945	1952	725	24.3	43.6

German children in Wuppertal in 1947. She compares the results with similar studies on 5 year-old London children in the same year. The percentages of children who had no carious teeth were about the same, being 28.4 in Wuppertal and 28.1 in London. The percentages of teeth with caries were 14.2 and 20.3, respectively. Another difference found was that only 9.4 per cent of London children showed the mildest form of caries (grade 1) compared to 22.7 per cent of the German children. The structure of the teeth in the latter children was also a little better than that in the London children. The author ascribes this to the ". . . good calcifying properties of their ante-natal and early post-natal diet." She puts stress on special allocation of milk and vitamin D which were available to the mothers and children between January, 1942, and 1945 and assumes that this has been achieved by a more rigid regimentation of mothers than would be possible in England. "However, the quality of the diet after the War had deteriorated, . . . and the large proportion of new caries seen may be attributed partly to the reduction in the calcium content of their food and the virtual absence of any additional sources of vitamin D."

The German children were about the same height as the London children, but weighed 1 kg. less.

The good calcifying property of the diet during the tooth-mineralization period, which H. Mellanby assumes, does not agree with the statement of Kantorowicz. (*See* p. 424.)

ITALY

Schour and Massler (1947) made some dental studies in Italy during 1945. They report caries rates that are one-half to one-seventh those published by Klein from Hagerstown in the United States. No comparison was made with earlier studies in Italy. Children showed various signs of malnutrition, and the authors ascribe the low caries rate to the very low consumption of sugar.

Dental Caries in Adults

As far as the present author knows no study has been pub-

lished on dental caries in adults during the War, except for a few statements concerning repatriated prisoners. Morgan, Wright, and Ravensway, 1946, report from a study of 4,618 repatriated American prisoners from the Far East that no unusual pathologic conditions of the teeth were manifested. The number of carious teeth was less than that of the same age group living under normal conditions, which might be accounted for by the small amount of sugar in the diet. This was a striking deviation from the average picture of loss of weight, neurologic changes, a high incidence of pulmonary tuberculosis, muscular wasting, dermatologic manifestations and psychological changes, they write. Helwig-Larsen and coworkers (1952) state in their extensive report on famine diseases in Danish prisoners in German concentration camps that no increase in dental caries could be attributed to the highly deficient diet, both in quantity and in quality.

Discussion of the Causes of Changes in Caries Frequency during and after World War II

As has been shown, a reduction in the caries rate took place in some countries during the last years before World War II; it also has been demonstrated that the reduction is far more pronounced during the war years and that the amount of caries increased rapidly from the end of the War or a year or two later.

In discussing the causes of the reduced caries incidence one has to take into consideration both the *resistance of the tooth* and the *direct attacking factors.*

The first experimental evidence of the importance of the tooth resistance factor in producing dental caries was given by Howe, 1924. In monkeys born and raised in their natural habitat he was unable to produce caries in spite of feeding them diets rich in sticky sugar so that the teeth were covered with heavy plaque.

The resistance of the tooth is laid down during the development and mineralization of the tooth. The last process has been demonstrated by the use of isotopes, for instance, to con-

tinue in the post-eruptive period. Mineralization is dependent mainly on the nutrition which, in turn, is regulated by the kind and amount of food eaten as well as by the physiological processes going on in the body. These last may be disturbed, for instance, by diseases of various kinds.

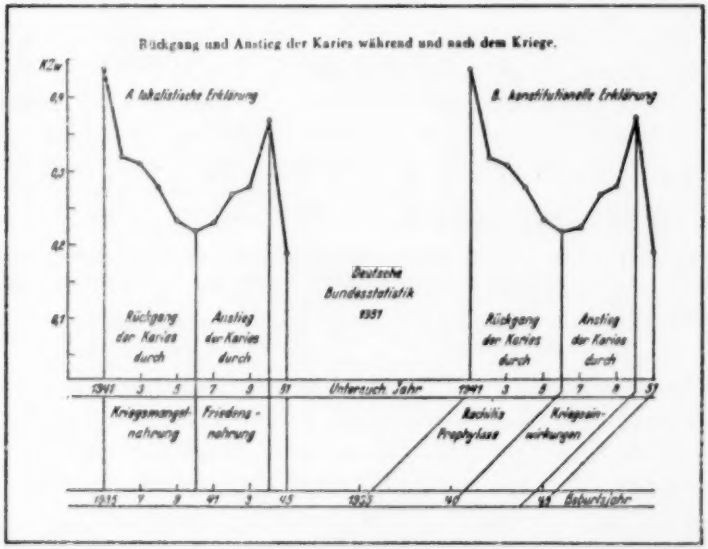
The resistance of the tooth probably is laid down chiefly during the pre-eruptive period. This period again has to be divided into the formation of the crown, that is, before the atrophy of the ameloblasts, and the rest of the pre-eruptive period. The first is probably the most important one, at least it is during this stage that the hypoplasias are developed.

The direct caries-producing factors, according to the majority of investigators, are the fermentable carbohydrates and the acid-producing bacteria. Kite, Shaw, and Sognnaes (1950) have clearly shown that caries are not produced in rats without food in the mouth, and Orland and collaborators (1954) have demonstrated that micro-organisms are necessary in order to produce caries in rats. The direct caries-producing factors act on the erupted tooth only. Consequently, in discussing our problem, we have to take into account that the resistance-governing factors and the direct caries-producing factors affect the teeth chiefly at quite different periods. When the incidence of caries decreases during the War it is not necessarily due to factors operating exclusively during this time. It could be the result of factors influencing the resistance of the tooth and acting years before, that is, during the primary mineralization of the tooth. This view has been most strongly stressed by Kantorowicz (1952 and 1953). As previously stated, his reports show that the caries prevalence decreased steadily up to the end of the last War. The decrease, however, is most pronounced during the War, just as has been demonstrated for Scandinavia. He ascribes the reduction in caries before the War to the improved care of infants and pre-school children, affecting chiefly the nutritional condition. He stresses particularly the distribution to mothers and children of vitamin D, through Vigantol, which had taken place during the last 8 to

10 years before the War. To this prophylaxis against rickets Kantorowicz ascribes the pronounced decrease in the amount of caries during the War. He further states that the deteriorated nutritional condition for pregnant and lactating women and for infants and pre-school children during the war years is the cause of the increased caries rate from 1946. (*See* Figure 46.) This statement on the poor nutritional condition during the mineralization of the teeth does not agree with the findings of surprisingly good surface enamel structure in 5 year-old children in Wuppertal by H. Mellanby, *see* previous discussion on Germany. The last author attributes her findings to good nutritional condition for the early tooth mineralization.

Kantorowicz does not consider the decreased consumption of sugar and other fermentable carbohydrates during the war

Fig. 46. *After Kantorowicz.* Figure A (left). Ernährungstheorie explains the caries reduction on the basis of the assumed vitamin richer and sugar poorer diet during the War, but does not take into account that the enamel of the most important teeth has been built long before the War as is illustrated in Figure B (right). The decrease in caries has to be referred to influences in peace time and the increase to influences during war. (According to Kantorowicz.)



Year	Pregnant Women			Pre-School Children		
	Number Examined	Hemoglobin Less Than 12 gms. per 100 cc.		Number Examined	Hemoglobin Less Than 12 gms. per 100 cc.	
		Number	Per Cent		Number	Per Cent
1939	101	23	23			
1940	85	15	18	137	17	12
1941	155	20	13	296	48	16
1942	201	13	6	318	19	6
1943	202	23	11	453	26	6
1944	333	26	8	589	13	2

Table 54. The frequency of anemia in pregnant women and in pre-school children at Sagene Health Station in Oslo, 1939–1944.

as a causative factor in the reduced caries rate. He speaks of this interpretation as the "Localistische Erklärung" versus his own as the "Konstitutionelle Erklärung."

Kantorowicz also transfers the same view on the causative factors to the changes in caries frequency demonstrated in the Scandinavian countries during and after the War. v. Kreudenstein (1952) has about the same opinion as that of Kantorowicz.

The Tooth Resistance Factor. How can the explanation of Kantorowicz fit into the condition in Norway? As has been shown in the section on diet, pregnant, and lactating women and children 0–5 years of age had a ration which fully met the requirements of protein, calcium, phosphorus, iron, and vita-

Table 55. Rickets or osteoporosis in infants 0–2 years old at Sagene Health Station in Oslo, 1939–1944.

Year	Pre and Postnatal Supervision			Postnatally Supervised Infants		
	No. Examined	No. with Osteop.	Per Cent	No. Examined	No. with Osteop.	Per Cent
1939	52	1	1.9	328	52	15.9
1940	123	3	2.4	576	49	8.5
1941	191	7	4.7	719	16	2.2
1942	176	2	1.1	618	11	1.8
1943	320	3	0.9	1,040	14	1.3
1944	465	4	0.9	1,407	23	1.6

mins A, B_1, C and D. The consumption of vitamin D by these groups was no doubt higher than before the War. Special medical studies on mothers and young children at Sagene Health Station in Oslo during the War did not show any impaired health status. On the contrary, signs of improved health were found, as is seen from Table 54. (K. U. Toverud, 1945, and G. Toverud, 1950.) Neo-natal mortality and total infant mortality showed a decrease. Of special interest is the very low frequency of rickets or osteoporosis in 0–2 year-old children shown in Table 55. The overall picture of the health of preschool children outside this health center also was good compared with that of older school children.

As shown in Table 36 and Figure 42, in Oslo there was a slight decrease in the caries rates for permanent teeth of 7 year-old children in the period between 1929–1930 and 1939–1940. The magnitude of this decrease, however, cannot at all be compared with that during the war years. The decrease in caries before the War may be explained on the basis of the increased health service for pregnant and lactating women and young children. The teeth showing a great reduction in the occurrence of caries during the War no doubt have been affected by such factors during the developmental period. However, there is no information at hand to suggest that special nutrition factors were introduced between 1933 and the outbreak of the War to cause such an improvement in the dental condition as is demonstrated in Figure 42 for Oslo.

In discussing the resistance factors in relation to the caries rate, it has to be remembered, as stated above, that the mineralization of enamel does not take place only during the time when the ameloblasts are functioning, but also after the cells have atrophied and the enamel is bathed in the tissue fluid before eruption of the tooth. This has been demonstrated by Brudevold and collaborators (1956) with respect to fluorine. It has also been shown most conclusively, by use of isotopes, that the enamel may take up different ions after eruption; Pedersen and Schmidt-Nielsen (1941); Berggren (1947); Bar-

telstone and collaborators (1947); Ericsson (1954); Sognnaes, Shaw, and Bogoroch (1955), and others.

The authors last mentioned have clearly shown in monkeys the difference in uptake of radioisotopes according to the developmental age of the dental tissue. Only five hours after intravenous injection of P^{32} the enamel of unerupted teeth, even though fully formed and nearly fully mineralized, was the site of a remarkably high P^{32} concentration throughout the whole thickness, an activity only exceeded by the alveolar bone. Furthermore, an increasing specific activity of P^{32} was found from the incisal tip of unerupted incisors to the cervical part of the crown (the youngest part of the enamel cap). This gradient was thought to reflect greater penetration and exchange as well as submicroscopic growth of the inorganic crystals.[6] In fully erupted molars the authors could prove by the use of radioactive tracers the penetration through the teeth from the pulp outwards as well as from the saliva inwards. When saliva had access to the enamel, the outermost layer of the enamel had the highest concentration of P^{32}. From this, the authors state: ". . . our results are believed to suggest that the relationship between enamel and saliva constitutes a solid-liquid system similar to that existing between the mesenchymal hard tissues and extracellular connective tissue fluid."

As is seen, the teeth are under the influence of biochemical and biophysical processes after eruption as well as before eruption, processes which determine the resistance to decay. In the preeruption period general metabolic conditions alone are responsible for these processes. Posteruptively, however, environmental factors also play a part, and, of these, saliva probably is the most important one. Unless the enamel surface is free from heavy debris, saliva cannot come in contact with the enamel and no ion exchange can take place. With a reduced consumption of plaque-producing foods and an increased consumption of tooth cleansing foods during the War,

[6] Sognnaes has furthermore demonstrated a corresponding difference in P^{32} uptake in erupted teeth in monkeys. (Personal communication.)

the conditions favoring the positive action from saliva may be considered better than before. This would be true in spite of the fact that tooth brushes were of poor quality and probably not used to the same extent as before.

It will be apparent that it is rather difficult to distinguish between the role of the resistance-producing factors and the direct caries-producing factors in changing the caries rate since both types of factors may be operating at the same time.

The various specific factors required for building up optimal resistance of the tooth are not known. Among the trace elements discussed, *fluorine* has definitely been demonstrated to be very potent, reducing the caries rate by 60–65 per cent when present in the drinking water at a concentration of 1.0–1.2, mg. F per liter: Ast, Smith, Wachs, and Cantwell, 1956; Arnold, Dean, Jay, and Knutson, 1956; Hutton, Linscott, and Williams, 1956.

In discussing the possible increased resistance of the teeth during the war years in Norway, the intake of fluorides therefore has to be considered. The addition of calcium carbonate (0.4 per cent) to the flour represented according to analyses (Sunde) about 0.01 ppm F. The fluorine content of the high extraction-flour varied with the kind of grain used and the place where it was grown. The flour-mixture with the added calcium carbonate used during the War had an average fluorine content between 0.08 and 0.14 ppm. That is only slightly higher than before the War. With an average intake of 220 gms. flour, this gives 0.02–0.03 mg. F per day. Danielsen and Gaarder (1955) publish somewhat higher figures in flour used after the War. The increased consumption during the War of potatoes, vegetables and, particularly fish, raised the intake of fluorides. Danielsen and Gaarder have given the following figures of fluorine content of these food items from Western Norway:

Cabbage	0.04 ppm F
Carrot	0.21 ppm F
Potato—Without the Peel	0.09 ppm F

Potato Peel	0.90 ppm F
Cod, Fillet	0.72 ppm F
Cod, Skin	8.20 ppm F
Mackerel, Fillet	0.88 ppm F
Mackerel, Skin	10.80 ppm F
Herring, Fillet	0.83 ppm F
Sardines, Whole, Canned in Oil	5.20 ppm F
Sardines, Whole, Canned in Tomato Sauce	7.1 ppm F

Based on analyses of the various foods, the authors have calculated that the total fluorine intake by children 5–8 years would amount to 0.219 mg. and by people above 14 years of age to 0.312 mg. Tea, tomatoes, and canned sardines are not included.

The main difference affecting the fluorine content, between the diet on which the above estimates have been based and the war-diet is the amount of fish. By increasing the fish to 300 gms. from the stated 30 gms. for children, and 100 gms. for adults, the fluorine figure will be 0.435 for children, and 0.472 for adults. These probably have to be taken as maximum amounts of fluorine except in families where it had been customary before the War, or became so during the War, to use chiefly unpeeled potatoes and fish with the skin and also the bones of small herrings. Except for a few localities, the drinking water in Norway is very low in fluorides.

It may be concluded that the increase in fluorine intake through the special war-diet has not been sufficient to raise the resistance of the teeth to any appreciable degree.

Susceptibility to caries has been demonstrated by Sognnaes (1948) to be influenced by the sugar content of the diet. When hamsters were fed a diet containing 67 per cent sucrose but otherwise having all known nutrients in sufficient amount during the developmental period of the teeth, susceptibility to caries increased as compared with animals fed a stock diet. The ratios of caries scores to that for the stock diet, was found to be 20, 10 and 2, respectively, when the high sugar diet was

introduced at the start of gestation, at the start of lactation, and at the weaning of the offspring. Giving the high sugar diet to female hamsters even some time before mating seemed to result in the highest caries score.

If a similar relationship holds for human beings, there could be a possibility that the low sugar diet during the War had a beneficial influence on the factors determining the resistance of the tooth. It is a question, though, whether the amount of sugar in the diet before the War was high enough to interfere with the resistance-producing processes.

In spite of the fact that the nutritional condition in the war years may be considered to have been better during the developmental period for the teeth erupted after the end of the War, these teeth show an increased caries rate. This increase, as well as the decrease during the War, most probably has to be ascribed chiefly to other factors, namely changes in the direct caries-producing factors.

Direct Caries-Producing Factors. As mentioned above, animal experiments have shown that caries do not develop unless the two following factors are present: carbohydrates and microorganisms.[7]

Carbohydrates. The previous discussion of diets during the War has shown that the total amount of carbohydrates did not decrease materially. There were, however, great changes in the relative amounts of the various forms of carbohydrates used. Since most investigators have put *sugar* and *sugar products* in first place in connection with the caries process, these will be dealt with first. In Norway, the daily sugar ration was very small, only 34–43 gms. per person for home use in the years 1941–1948. (Table 39.) Corresponding figures on amount used at home are not available for the whole country before the War. In the report of Galtung Hansen's in 1936–1937, we find the amount of 71 gms. It has been estimated, however, that the amount of household sugar used before the War was more than double that available during the War. Table 56

[7] No bacteriological studies have been made.

gives figures on the amount of total sugar, sugar for home use, for industry, for chocolate and candy factories, and for manufacturing of juice and marmelade, all calculated per person per day, before the War, during the War, and after the War. For all categories, there is a great decrease during the War and a gradual increase after the War with amounts finally surpassing the pre-war values. The total amount of sugar per person per day in 1944 was 36 gms. compared with 100 gms. as an average for the years 1934–1938. The greatest relative decrease is found in the amount for industry as a whole and for the producers of chocolate and candy. The consequence of this was the almost total stoppage in production of all kinds of candy, coughdrops, cookies, pastry, sweet crackers, etc. From 1942, all candy was rationed and the amount on ration for the wartime was negligible. All of these are products taken chiefly between meals by children and teenagers. Experimental studies by Stephan and Miller, 1943; Fosdick, 1949; Strålfors, 1948, 1950; Ericsson, Jared, and Stjernström, 1954; Krasse, 1954, and many others have demonstrated the rapid

Table 56. The amount of sugar used in Norway before, during and after World War II, in grams per person per day.

Year	Total	Household	Industry	Chocolate and Candy	Marmalade, Juice
1938	91				
1939	80	38	11	5	3
1940	69	43	12	5	3
1941	66	42	11	5	3
1942	57	30	8	3	3
1943	52	36	4	0.9	2
1944	36	27	1	0.1	0.7
1945	52	42	3	1	0.8
1946	57	41	9	3	3
1947	58	40	10	4	3
1948	64	40	10[a]	4	4
1949	69	43	12[a]	7	2
1950	74	43	12[a]	6	3
1951	76	44	13[a]	7	3
1952	87		17	7	3
1953	99			6	3

[a] Deducted for export.

production of acid in the dental plaque after taking sugar and various sugar products. Ericsson has particularly stressed the caries-producing effect of frequent use of cough drops in persons who have taken such sweet tablets as a substitute for smoking. The most convincing results from experimental studies on a large clinical material on the effect of sugar are those from the Vipeholm investigation in Sweden, B. Gustafsson and collaborators (1954). These studies on adult patients clearly demonstrate an increase in new caries as well as the enlargement of cavities in adults by the frequent intake of sticky sugar products. After taking away the sweets, the caries activity changed to the pre-experimental state. Lundquist, 1952, studying the sugar clearance in the saliva of these individuals found a positive correlation between the frequency of eating sugar, the duration of sugar in the saliva, and the amount of new caries.

On the basis of all these studies and many others, there cannot be any doubt that the great reduction in sugar consumption during the War was an important factor in reducing the caries rate. In the Vipeholm data for adults, the high sugar intake at meals has had only a slight influence on the caries picture. The report, however, stresses that this need not be the same in children. Based on the Vipeholm studies as well as on the mode of acid production in the dental plaque after ingestion of sugar and sugar products, elimination of between-meal eating of sugar products during the War probably was of greater importance than the decreased amount of sugar used in the food at mealtime.

When children during the War wanted something between meals, they had to take apples, carrots, turnips, raw potatoes, or other vegetables. Instead of leaving a sticky deposit of high sugar concentration on the teeth, these foods cleansed the teeth and stimulated the salivary glands to produce a saliva greater in amount and in buffering capacity, Sand, 1946.

The absence during the War of various kinds of sandwich spreads of high sugar concentration may also have played a

role as such products produce a high concentration of lactic acid in the plaque, Toverud and Hagen, 1957.

Among the carbohydrates, the wartime *bread* has to be mentioned. As stated previously, flour was chiefly of 95 per cent extraction. The imported grain was of poor quality most of the time and the bread had to be made with much acid. The bread, which could not be sold less than twenty-four hours after baking, was not very palatable. The high extraction flour contained a good deal more cellulose than usual; and, consequently, this bread should be expected to have a certain cleansing effect on the teeth and needed greater chewing force. On the other hand, the poor quality of the flour, often resulted in a sticky bread. The acid taste of the bread, together with the more vigorous chewing, probably had some stimulatory action on the salivary glands producing more abundant and buffer-rich saliva. However, this effect on saliva was caused in greater degree by the chewing of root vegetables and raw potatoes.

White flour of low extraction could be bought only for children up to 2 years of age and for adults by prescription of physicians. Farmers were allowed to use their own grain which was of better quality than the imported and thus they were eating a bread of higher quality than people who had to buy.

There can be no question of high chewing force being a positive factor in preventing dental caries. However, there is no basis for considering the physical character of the war-diet to be the main factor in reducing the caries rate, as pointed out by Neumann, 1950.

The Time Relationship between Changes in Sugar Consumption and Changes in Caries Rates. As shown in Tables 45, 47, and 50 and Figures 44 and 45, there is a very close time relationship between the curve for annual consumption of sugar and the curve for annual caries rates from the start of the War to the end of the War. Toward the end, or after the War, the sugar curve starts to increase before the caries curve. Since the caries frequency had started to decrease before the War, it is

rather difficult to identify the exact time at which war conditions affected the caries rate. However, there is a definite break in the caries curve in 1941 from the earlier slope, so it should be safe to state that the effect of the War was clearly noticeable a year after the outbreak of the War and the introduction of the complete rationing system. This delayed reaction of the teeth to a decrease in sugar consumption at the beginning of the War and to the increase in sugar consumption after the War has been taken as evidence against the changes in sugar consumption *per se* being a main causative factor, Sognnaes, 1948. However, since the acid produced in the mouth from carbohydrates is caused by micro-organisms, it takes some time for the mouth flora and the total micro-biological status to change in the mouth. The lag in time for the increase in caries after the War also may be caused partly by an increased resistance of the teeth.

The Inter-Relationship between Tooth Resistance and Environmental Conditions as Factors Affecting Caries Rates

It has been shown in Part II, (Toverud, 1957), that the curves for caries rates in older children increased later in the post-war years than the curves for the younger children. This difference seemed to suggest that teeth of the older children which had developed during the War had an increased resistance. Cross sectional figures on caries prevalence at different ages however, do not give a real basis for studying this question as has also been pointed out by Schulerud (1949) and Parfitt (1954). Furthermore, as has been stressed above, it is rather difficult to differentiate between the action of resistance governing factors and direct caries producing factors since both may be acting at the same time.

In order to study relative changes in caries activity in the teeth of children of different ages in specific years during and after the War, the annual incidence of caries is needed, that is, the rate of occurrence of new caries in the teeth within one

year. Ideally, incidence rates should be obtained from true longitudinal studies, that is, from examinations of the same children from year to year. The present investigation on Norwegian school children is only partially longitudinal since it was not possible to obtain consecutive annual examinations for all children.[8]

Cities and villages for which data have been combined were selected to provide populations with a minimum of variation in the school years for 1940–1941 to 1948–1949, but examinations from a grade or a school, or even a community are missing in one or more years. For the combined cities and combined villages, approximate annual incidence rates are obtained by using the increment in the caries rate between two successive ages from one year to the next. Trends in these annual increments during war and post-war years for younger and older school children are examined in an attempt to gain more evidence on differences in the relation of changing conditions to changes in caries activity in the teeth of the two groups of children.

Since in most communities, only children in the first and second grades and in the sixth and seventh grades were examined, yearly increment could be computed only for children aged 7 in one year and aged 8 in the next year and similarly for children 12 and 13 years of age. In addition, the four-year increment from age 8 to 12 years has been computed for cohort groups; for example, the increment between the caries rate for 8 year-old children in 1940–1941 and that for 12 year-old children in 1944–1945. Because of the limited age groups available for study and for other reasons, the incidence of caries in the first permanent molars has been studied, and particularly the increment in surfaces attacked by caries.

The prevalence of carious surfaces (DMF surfaces for 100

[8] The investigation was set up for a longitudinal study, but, as described in Part I, so many difficulties arose that it was not possible to follow through with the original plan. Some communities dropped out of the study, some were added late and in others, some children examined in one year were not examined in the next year.

total surfaces) in first permanent molars at ages 7, 8, 12, and 13 years for boys and girls combined in "cities" and in "villages" in each year from 1940–1941 to 1948–1949 and in 1951–1952 and 1952–1953 is shown in Table 57. Rates for the last two years are not strictly comparable to the earlier period, since they are for the "reduced" groups, but there was little difference between rates for the total and reduced groups in the earlier period. The absolute increments, that is the incidence of caries affected surfaces, per 100 total surfaces, from age 7 to 8 years and from 12 to 13 years, and from 8 to 12

Table 57. Prevalence of DMF surfaces in permanent first molars at ages 7, 8, 12 and 13 years for children in cities and in villages examined from 1940–1941 through 1948–1949, and in 1951–1952 and 1952–1953, and incidence of new carious surfaces from 7 to 8 years, 8 to 12 years, and 12 to 13 years.

School Year Ending	Per Cent of Total Surfaces DMF at Specified Age				Increment in Per Cent DMF between Specified Ages			Per Cent of Caries-Free Surfaces Becoming Carious		
	7 Yrs.	8 Yrs.	12 Yrs.	13 Yrs.	7 to 8	8 to 12	12 to 13	7 to 8	8 to 12	12 to 13
	cities									
1941	23.3	29.7	47.1	50.8						
1942	18.9	27.9	47.7	48.0	4.6		0.9	6.0		1.7
1943	16.5	26.2	43.2	47.8	7.3		0.1	9.0		0.2
1944	14.4	21.1	42.9	47.5	4.6		4.3	5.5		7.6
1945	15.5	19.9	40.1	45.3	5.5	10.4	2.4	6.4	14.8	4.2
1946	12.8	18.2	37.8	43.2	2.7	9.9	3.1	3.2	13.7	5.2
1947	13.6	17.9	35.8	39.2	5.1	9.6	1.4	5.8	13.0	2.3
1948	15.9	20.4	30.6	37.7	6.8	9.5	1.9	7.9	12.0	3.0
1949	13.9	21.2	29.5	33.6	5.3	9.6	3.0	6.3	12.0	4.3
1952	19.4	26.6	42.4	41.1		22.0			27.6	
1953	19.3	27.3	40.4	47.0	7.9	19.2	4.6	9.8	24.4	8.0
	villages									
1941	23.2	28.1	45.7	49.4						
1942	19.8	27.5	47.6	49.8	4.3		4.1	5.6		7.6
1943	15.2	23.1	45.5	50.0	3.3		2.4	4.1		4.6
1944	15.1	18.8	44.8	49.6	3.6		4.1	4.2		7.5
1945	13.7	17.3	41.4	47.6	2.2	13.3	2.8	2.6	18.5	5.1
1946	8.9	14.7	38.5	44.5	1.0	11.0	3.1	1.2	15.2	5.3
1947	11.4	15.6	37.2	42.4	6.7	14.1	3.9	7.4	18.3	6.3
1948	12.7	17.4	31.2	38.3	6.0	12.4	1.1	6.8	15.3	1.8
1949	15.2	21.2	31.6	34.6	8.5	14.3	3.4	9.7	17.3	4.9
1952	17.9	21.2	35.3	40.4		17.9			21.7	
1953	20.5	23.8	41.8	41.6	5.9	20.6	6.3	7.2	26.1	9.7

years also are shown in Table 57. The annual prevalence rates for these groups of children show some erratic fluctuations[9] which produce rather large irregularities in the increments from year to year. The prevalence rates have been smoothed[10] in order to show trends more clearly and the smoothed rates are plotted in Figure 47.

The increase in the percentage of carious surfaces from age to age is shown in Figure 47 by the lines connecting the rate at age 7 with the rate at age 8 in the next year, then with the rate at age 12, four years later and finally with that at age 13, one year later. Both in cities and villages, the increment from 7 to 8 years is least in 1944–1945, continues small in 1945–1946 and increases thereafter. Before 1944–1945, the annual increment showed a steady decrease and was less in villages than in cities; whereas in cities the increment was fairly constant but less than the difference between rates for 7 and 8 year-olds examined in the first year, 1940–1941; and less than in the post-war years.

At the bottom of Figure 47, the years of mineralization of the first molars are indicated for 7 year-old children examined in the specified years. Since the mineralization of this tooth starts at birth and the tooth erupts at 6 years, in 7 year-old children the tooth has had 6 years of pre-eruptive mineralization and one year of post-eruptive maturation. As is seen, the caries rate is decreasing for teeth having their pre-eruptive mineralization exclusively before the War or partly before and partly during the War. But these teeth have erupted during the War. The increase in caries rate starts with teeth which had the pre-eruptive mineralization during the War and

[9] Some variation in annual prevalence rates at any specific age would result from ordinary sampling variation, but, in these data, the rates may be affected also by changes in representation from the various communities in different years.

[10] Rates were smoothed by using a three-year moving average from 1940-1941 to 1945–1946. This curve was extrapolated to obtain a rate for 1940–1941. Since the rates increased sharply after 1945–1946 or 1946–1947, averages for two years were used and rates for each year were interpolated from the trend for the mid-year values. At ages 12 and 13 years, a three-year moving average was used from 1940–1941 to 1948–1949 and the curve was extrapolated at each end. No adjustment was made in rates for 1951–1952 and 1952–1953.

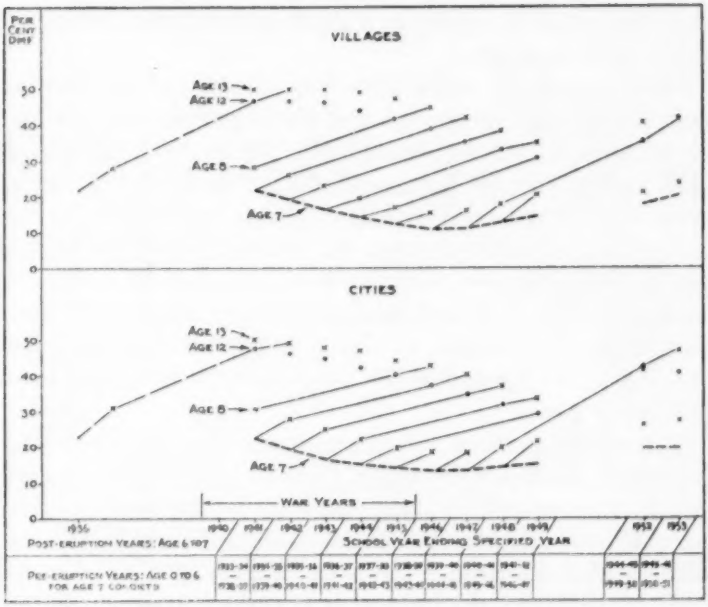


Fig. 47. Per cent of total surfaces of permanent first molars affected with caries for children aged 7, 8, 12 and 13 years (smoothed rates 1941–1949) in cities and in villages in Norway. Lines connecting rates at age 7 with older ages indicate increments in caries with advancing age for approximately the same group of children. Period of development of molars is shown for 7 year-olds in each school year.

erupted after the War. The increment in new surface caries follows about the same lines. The lowest increment is found in 1945 or 1946 in teeth with the longest developmental period during War and also erupting during War.

At 12 and 13 years, the per cent of DMF surfaces of total surfaces does not start to decrease materially until 1944 or 1945 and continues to go down through 1949. In 1952 and 1953 a big increase is noticed. The absolute increase[11] in surface caries from 12 to 13 years is quite small and does not show any real change in the period 1941–1949. The increment

[11] The increment in new surface caries demonstrated here in first permanent molars in children from 12 to 13 years should not be compared with other increment studies based on all the teeth combined, as the post-eruptive tooth age varies greatly for the different teeth.

from 1952 to 1953, however, is much greater than in war and early post-war years.

The increment in caries from 8 to 12 years of age does not show any change during the first study period, but a definite rise is shown for the four years from 1948 to 1952. Taking the DMF surface rate for 8 year-old children in 1940–1941 as representative of the pre-war normal value and setting it back four years to describe the approximate increment for 12 year-olds in 1941, it is seen that this line is steeper than those for the period 1941–1949 and has a slope very much like that of 1948–1952. This illustrates clearly a greater increment from 8 to 12 years of age before the War and after 1948 than in the in-between period.

As has been pointed out in earlier studies, and particularly stressed in the Vipeholm study, Gustafsson (1954), the caries activity is most correctly expressed as the per cent of caries-free surfaces being affected during a certain period. This rate will be called the surface incidence. Figure 48 illustrates this mode of expressing the increment of surface caries in the first permanent molars for the smoothed DMF surface rates in the same groups as in Figure 47.

Surface incidence from 7 to 8 years decreases from 1941–1942 to 1944–1945 and then increases rapidly to 1947–1948 in villages. In cities the decrease is more slow, and the values for 1945 and 1946 are the same. The increase in cities is continuous through 1949 and the value for 1953 is still higher. In villages the last figures are somewhat irregular. The trend of these curves confirms in the main what has been illustrated in the preceding Figure.

For ages 8 to 12 years, the average annual surface incidence is shown. In the four-year periods ending 1945 through 1949, this rate shows no change; but in the periods 1948 to 1952 and 1949 to 1953, the rate has increased very sharply.

The first molars of the 12 year-old children in 1946 to 1949 erupted during the War; those of 12 year-olds in 1952 and 1953, for which the surface incidence increased greatly, erupted

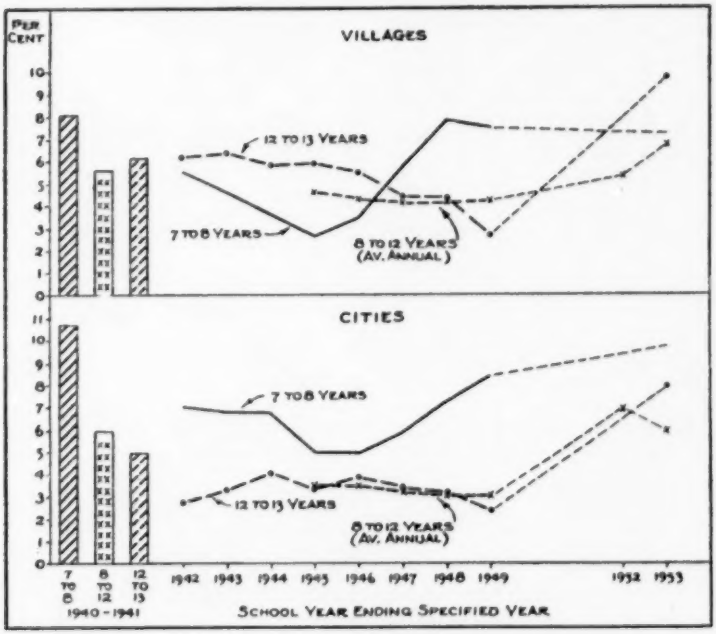


Fig. 48. Incidence of new carious surfaces among caries-free surfaces of permanent first molars from age 7 to 8 years, 8 to 12 years, and 12 to 13 years based on increases in rates for approximately the same children, in cities and in villages in Norway. (Smoothed data used for 1941 through 1949; and "reduced" groups in 1952 and 1953.) Bars at left are based on differences between ages for children examined in 1940–1941 and represent incidence of new caries assuming no significant trend in age-specific rates in previous years.

after the War. Surface incidence for the period ending in 1945 is for molars that erupted immediately before the War.

At age 12 to 13 years, caries activity measured by incidence in caries-free surfaces shows a continuous decrease in villages from 1945–1946 through 1948–1949 and a very great increase in the 1952 to 1953 period. In cities, the surface incidence is irregular in the early years and the low values in the first two years make the trend indefinite, but the trend is consistently downward during 1947, 1948, and 1949. In the last post-war period, 1952 to 1953, there is a pronounced increase in surface incidence in the cities.

Year of Increment	Change in Increment	Pre-Eruption Mineralization			Eruption During		Carbohydrate Factor in Post-Eruption Period
		Pre War	War	Post War	War	Post War	
1941–1942	Decreasing	+++			++		Decreasing
1942–1943	Decreasing	++	+		++		Decreasing +
1943–1944	Decreasing	++	+		++		Lowest
1944–1945	Lowest	+(+)	(+)+		++		Lowest
1945–1946	Lowest (Increasing)	+	++		+	+	Increasing
1946–1947	Increasing	+	++			++	Increasing +
1947–1948	Increasing		++	+		++	Increasing ++
1948–1949	Increasing		++	+		++	Increasing +++
1952–1953	Increasing			+++		++	High

Table 58. Time relationship of the mineralization periods and the carbohydrate factor and their relation to the yearly increment in total surface caries in first permanent molars in boys and girls from 7 to 8 years of age.

The much higher incidence of caries in 1953 than in the earliest years, based on caries-free surfaces, may be explained by the fact that a greater number of caries susceptible surfaces were caries-free in 1949 than at the beginning of the War.

In this age group the first molars not showing any decrease in incidence in the years 1942 through 1945 erupted before the War but the teeth showing a lower incidence after the War erupted during the War. The teeth with a greatly increased incidence in 1953 erupted after the War.

The time relationship between the mineralization periods

Table 59. Time relationship of the mineralization periods and the carbohydrate factor, and their relation to the yearly increment in total surface caries of permanent first molars from 12 to 13 years in boys and girls combined.

Year of Increment	Change Increment	Pre-Eruption Mineralization			Eruption during		
		Pre War	War	Post War	Pre War	War	Post War
1941–1942	None	+++			+		
1942–1943	None	+++			+		
1943–1944	None	+++			+		
1944–1945	None	+++			+		
1945–1946	Decrease	+++				+	
1946–1947	Decrease	++	+			+	
1947–1948	Decrease	++	+			+	
1948–1949	Decrease	+	++			+	
1952–1953	Increase		++	+			+

and the carbohydrate factor after eruption of the tooth and their relation to the yearly increment in caries is summarized in Table 58 for 7 and 8 year-old children. Decreasing increments in carious surfaces coincide with decreasing carbohydrate factor. The teeth concerned have had the pre-eruptive mineralization period exclusively before the War or partly before and partly during the War but they all erupted during the War. Increasing increments likewise follow the increasing carbohydrate factor. The pre-eruption mineralization of these teeth has taken place partly before, partly during and partly after the War; for the last group (1952–1953) after the War exclusively. In all these instances the teeth have erupted after the War.

Table 59 presents a similar summary of relationships for 12 to 13 year-old children. The first molars which in the first four years show no change in increment have had their pre-eruptive mineralization before the War and erupted before the War, before any carbohydrate rationing. At the time of examination, however, the carbohydrate factor was low and had been low for 2 to 5 years. The pre-eruptive mineralization of the teeth showing a decrease in increment has taken place exclusively before the War or partly before and partly during the War. The teeth erupted during the War when the carbohydrate factor was low. At the time of examination and for a period of 1 to 4 years before examination, the carbohydrate factor had steadily increased. The teeth examined 1952–1953 have had the pre-eruption mineralization partly during and partly after the War and erupted after the War when the carbohydrate factor again was high and stayed high for the whole post-eruptive period.

CARBOHYDRATE FACTOR

At Eruption	At Examination and Before
High	Low and Prev. 2 Yrs.
High	Low and Prev. 3 Yrs.
High	Low and Prev. 4 Yrs.
High	Low and Prev. 5 Yrs.
Low	Increasing; Prev. Yr.
Low	Increasing + 2 Prev. Yrs.
Low	Increasing ++ 3 Prev. Yrs.
Low	Increasing +++ 4 Prev. Yrs.
High	High, Whole Time

In the 7 and 8 year-old children the change in increment

followed closely the change in oral environment. However, that was not the case in 12 and 13 year-old children. For these older children, the increment did not increase during the four years of increasing carbohydrate factor. The interpretation of these findings in the 12 and 13 year-old children must be that the teeth in these children had obtained a resistance which was able to counteract to a certain extent the action of the direct caries producing factors. There is good reason for assuming that the increased resistance is due to the eruption of these teeth during the War, a period favorable for the early post-eruptive maturation, since other teeth functioning for 4 or 5 years in a low carbohydrate environment, but erupting before the War, did not show any decrease in caries increment. This should prove that the post-eruptive age of the tooth *per se* has not been the deciding factor.

In the 7 and 8 year-old children the decrease and increase in the annual increment of caries also coincide respectively with eruption during the War and after the War.

As stated before, the post-eruptive maturation of the enamel is assumed to be chiefly dependent on the action of saliva on the enamel surface. Besides the quality of saliva the tooth environment *per se* plays a role in this respect.

There cannot be any question of the direct caries producing factors having been the most powerful ones in determining the changes in caries rates and caries increments. However, there seems also to be good evidence for an increased resistance in a certain period which has modified the action of the local factors. Contrary to the statements of Kantorowicz, the increased resistance factor in the Norwegian material has been in operation *during* the War. In his discussion and conclusion Kantorowicz has taken into account only the two to three first years of the mineralization time and this is just a fraction of the whole period as has been shown above.

As was mentioned in Part II one objective of this study was to relate any changes in dental health status of the children

that might occur during the war years to differences in living conditions of the populations in the various types of communities studied. We were particularly interested in comparing city children with rural children as it was natural to expect that the rationing of food would restrict the use of very valuable farm products more in cities than in rural areas.

It has been shown in Part II (Table 23 and Figure 32) that there were differences in maximum percentage reduction among the various community groups. For the main groups; cities, villages (excluding Gjerpen) and rural, the initial DMF rates were fairly close. During the period of reduced rates the rural children showed the highest maximum reduction and the city children the lowest. The difference between cities and villages, however, was small.

Differences in conditions in the cities and in rural districts that would affect either the resistance factor or local factor should be considered in seeking to explain the greater reduction in caries in rural districts than in cities.

The rationing system allowed farmers to use a more liberal amount of their own products than was provided for others. As it was rather difficult for the rationing authorities to keep close control on the farmers' production, one may assume that the producers kept even more for their own use than the allotted amounts; particularly with respect to meat, bacon, flour and milk. Farmers, presumably, also had more unrationed foods such as vegetables and fruit. Therefore, the diet of the rural population would have been of higher nutritional value than that of the city population. The consumption of sugar and sugar products in rural districts most probably was equal to that in cities.

If better diet in rural districts did account for the greater reduction in caries during the war years, it does not appear that tooth resistance to caries was increased by this diet, since caries rates for the rural children increased very sharply immediately after the War. (*See* Figure 32, Part II.) Our sample of rural children was small and the changes in the amount of

caries during and after the War may not be typical for the rural population. The greater reduction in caries observed for the rural sample in this study than in the cities cannot be explained on the basis of general information on rural and urban conditions.

Interpretation by Other Writers of Caries Reduction in Scandinavia. The dental condition in Norwegian children during and after the War has also been studied and commented on by others: Sannerud (1945); Sognnaes (1948); Schulerud (1948, 1949, and 1950); Os (1950); and Alexander (1950). Alexander, the director of the school dental service in Gjerpen, a village included in the present study, emphasizes conditions favorable for mineralization of the teeth during the War, the reduction in the local caries producing factors such as sugar and sweets, and increased consumption of potatoes and vegetables. The last mentioned together with sour, salted, and dried food, increased the caries preventive properties of saliva. Schulerud in his extensive study on the causes of the reduction in caries rates during the War considers the reduction in total consumption and the frequency of eating sugar as the sole cause of the improved dental condition. He has correlated the low sugar intake during the War with reported diet studies from areas known to have high caries rates or low caries rates. He found the low caries rate to be associated with sugar calories not exceeding 150–160 per day (50–60 sugar calories per 1,000 calories). This holds true, for example, for the rather isolated Norwegian valley, Valle, in Setesdal (Høye, 1938) where Toverud, 1938, found exceptionally good teeth. About 25 per cent of the total population did not show clinical caries. The average sugar calories per day per person in Norway before the War was about 325 and during most of the War less than half of this amount.

Sognnaes, basing his studies on various reports on the dental condition during and after both World Wars, reaches the following conclusion: "The time relationship between the wartime reduction in dental caries and the reduction in the use of

refined carbohydrates (assuming there is a causative relationship) can best be explained by an indirect favorable influence on the development and maturation of the teeth, not by a change in the oral environment alone."

"The nature of the favorable influence is not known. It cannot be attributed to a uniform increase in the consumption of any previously demonstrated caries-preventing food or food factor." However, having had access to postwar reports on the caries prevalence only up to 1947, Sognnaes stresses that further data are needed before final interpretation can be made.

As to the "unknown" factor or factors mentioned by Sognnaes it is of interest to consider the findings of Sognnaes and Shaw, 1954, on the partial caries-preventing effect in rats replacing the commonly used salt mixture with the ash of the natural stock diet for addition to the purified high sugar diet. It is suggested that the observed caries protection may have resulted from the presence of certain trace elements in the ash mixture of the natural stock diet. Among these trace elements, however, the fluorine content has been ruled out as a decisive factor.

In his comments on the caries reduction in *Danish* school children, Pedersen, 1946, states that the reduced caries rate observed before the War (*see* Table 45 and Figure 44) has to be ascribed to improved hygienic conditions, particularly better nutrition for mothers and children, and that the augmented improvement of the teeth during the War is a combined effect of this and the special changes in the diet brought about by the War. Among the changes, the following was stressed: reduction in consumption of sugar, sugar products, and refined flour; and the substitution of more unrefined foods taken at regular meals. The more ample consumption of vitamins and milk by pregnant and lactating women and by young children during the War was also emphasized.

Sandberg, 1946, commenting on the rather slight decrease in caries rates in *Swedish* school children during the War, points to the reduction in sugar, syrup, candy, and low extrac-

tion flour and, on the other hand, to the increased consumption of milk, high-extraction flour, and vegetables. (*See* Tables 48, 49, and 50 and Figure 45.)

In reference to *Finland,* Wilska (1946) writes: ". . . the only nutritional factor capable of explaining the great reduction of caries incidence is the shortage of sugar." He states further that the curves of sugar consumption and caries incidence in various countries shows remarkable similarity. There exists neither a country with high sugar consumption and low or moderate caries, nor vice versa.

Vaenerberg (1957) has found in 7 to 14 year-old Finnish children, studied in the same schools, that the caries rate increased from 1947 to 1949 but decreased to 1954. He does not think that the local factor has changed sufficiently to account for this improvement, and alludes to changes in tooth resistance.

To summarize, three main views on causation are expressed in the various reports on changes in caries prevalence in children during and after World War II. One group of authors considers the nutritional factor, determining the tooth resistance, as the decisive one. Another group holds a view quite contrary to this and states that the changes in consumption of sugar and sugar products are the only cause. A third group takes an intermediate position and combines these two views, but considers the changes in the environmental condition to be the main cause.

As to the condition in Norway, the present author after careful studies of the changes in caries prevalence in children and changes in diet during and after the War reaches a conclusion confirmatory to the view last mentioned. A study of reports from other countries supports the general validity of this view.

General Summary and Conclusion

1. Dental studies have been carried out on 7–13 year-old Norwegian school children in cities, villages, and rural districts

during the years 1940–1941 to 1948–1949 inclusive and during 1951–1952 and 1952–1953. The total number of children each year has varied between 4,757 and 6,480. The object of the investigation was to see if war conditions in any way would influence the time of eruption of permanent teeth and the caries rate in deciduous and permanent teeth. In addition, a special study of the caries rate in a smaller group of 3–6 year-old children was conducted in 1939, 1944 to 1953 inclusive. The total number of children each year varied between 354 and 702.

Findings from the study of school children are reported for a group of cities, a group of villages, and a group of rural districts. Since dental conditions differed materially from the grouped data in the city of Trondheim and the village of Gjerpen, these communities have been dealt with separately. Several rural districts also were considered separately partly because of irregularities in years of dental examinations.

2. *Time of Eruption of Permanent Teeth.* The well known characteristic of higher eruption rates per chronological year in girls than in boys during the eruption period was found. From 1942–1943 or the following year a decrease starts in the average number of teeth per child in every age, 7–13 years, and the maximum decrease was reached in 1946–1947. A reversal has been observed in the following years. For all ages, except for the 7 year-olds, the 1940–1941 values had not been reached in 1948–1949. In one community, Gjerpen, studied 1951–1953, values for these last years continued to be lower than the initial ones, except for 13 year-old girls. Almost every specific tooth showed significant delay in eruption time. The bicuspids showed the greatest delay, and this coincides with extended persistence of the predecessors due to lower caries incidence and less destruction of these teeth during the War and first post-war years. With increased rate of early loss of deciduous cuspids and molars during the later years the number of corresponding permanent teeth erupted increased. The eruption of permanent first and second molars, not influenced

by deciduous teeth, was also delayed. It has been suggested, therefore, that a general factor, a nutritional one, also has been in operation. Data are cited on a corresponding retardation in height and weight of 8–14 year-old children in Oslo during the War. (*See* Part I, Tables 2–11 and Figures 1–11 and 17–18.)

3. *Caries Rates in Deciduous Teeth of School Children.* The per cent of caries affected deciduous cuspids and molars (missing teeth not counted) in 7, 8 and 9 year-old children had decreased by 1941–1942, and continued to decrease through 1946–1947 or 1947–1948. The mandibular cuspid in 7 year-olds showed the maximum percentage reduction, and the second mandibular molar in 9 year-olds showed the minimum reduction. The percentages are 77 and 20 respectively. During the last year of the first study period, 1948–1949, an increase in caries rates usually had taken place and in communities studied in 1951–1953 pronounced increases are observed for the molars, less for the cuspids. The initial values, however, had not been reached in any population group. (*See* Part I, Tables 12–15 and Figures 12–16.)

4. *Caries Rates in Permanent Teeth.* Since the whole dentition was examined only during the first two years and only the right half during the rest of the period, bilateral symmetry studies of DMF teeth were made for 1941–1942. These show only a very few significant differences for a few specific teeth and thus confirm earlier findings of bilateral symmetry of caries.

In most of the communities only children in the two lowest and the two highest school grades were examined. The 7 and 8 year-old and the 12 and 13 year-old children have been combined for the analysis of caries in permanent teeth.

The percentages of children aged 7 + 8 years who had no caries in the permanent dentition increased three to four times from 1941 to 1946. After 1946, the percentages decreased to 1949 but remained above the initial levels.

The average number of DMF teeth per child and also the

percentage of total teeth DMF showed a definite decrease in 1942, or in 1943, in almost every instance. In the younger age group (7 + 8 years), the minimum values usually were reached in 1946, whereas in the older age group (12 + 13 years) the lowest values occurred one to three years later. The percentage reduction in DMF rates was greater at the younger than at the older ages; and varied for different community groups from 31 to 83 per cent at the younger ages and from 27 to 64 per cent at older ages.

The reduction in the per cent of specific teeth DMF showed great variation from tooth to tooth. The teeth with the lowest caries susceptibility—the incisors, the first bicuspid, and the cuspid in the lower jaw—demonstrated the greatest reduction in caries rates. In the age group 12 + 13 years the drop was close to 100 per cent for several teeth. The smallest reduction was found for the first molars of 12 + 13 year old children. The percentage reductions in caries rates for the upper incisors in this age group were about the same for both the lateral and the central and were also of nearly the same magnitude as that for the first molars in the 7 + 8 year old children. Within groups of teeth of the same morphological type, the tooth with the lowest susceptibility showed the greatest reduction relatively.

The trend of the curves for the percentage of total surfaces DMF was generally similar to that for the percentage of teeth DMF. Here, too, an inverse correlation between caries susceptibility and caries reduction was found.

The rate of extraction of first molars dropped in all communities, and in most of them from a level, in the older age groups, of 40–45 per cent in 1941 to a point close to zero at the end of the first period, 1949.

A comparison of the various community groups showed that the greatest reduction in caries took place in the village community Gjerpen (not included in the main village group). Next in order came the rural group. The village group and the city group were about equal.

In all groups the per cent of total teeth DMF, the per cent

of total surfaces DMF, the per cent of specific teeth DMF, and the per cent of surfaces DMF in specific teeth increased during the second period of study, 1951–1952 and 1952–1953. Except for a few instances, the latest values did not, however, reach the levels of the initial rates.

The girls generally showed higher caries rates than boys. The maximum reductions in caries rates for girls and boys did not show any constant differences which might point to an actual sex differential in changes in caries status in response to the nutritional and environmental conditions operating during the period of study. (*See* Part II, Tables 16–34 and Figures 19–40.)

The annual reports from the school dental clinics in Oslo show the same trend in the caries rates for permanent teeth. Reports on the number of fillings inserted per child in all the school dental clinics of Norway each year also show the same trend. (*See* Tables 36–38.)

5. *Caries Rates in Deciduous Teeth of Preschool Children.* The reduction in caries rates in 3–6 year-old children was very great from 1939 to 1945, 1946 or 1947; during subsequent years, the rates increased. The decrease was greatest in 3 year-olds and for carious surfaces amounted to 76 per cent. The caries rate in 1953 had not reached the prewar rate in any age group. (*See* Table 35.)

6. *The General Health Status.* For comparison with the dental condition, the general health status of the Norwegian population during the War was reviewed briefly. The general mortality rate increased, but a decrease was found in mortality or morbidity rates for a number of diseases, particularly those which more or less have been linked to high intake of fat or of total calories. Previous averages for height and weight of children 8–14 years of age were not maintained during the War. (*See* Part I, Figures 17 and 18.)

7. *The Food Situation.* Since the relation of nutritional factors to changes in the frequency of dental caries is discussed, data have been given on food intake and nutritional values of diets in Norway during and after the War. Most of the foods

were rationed, but pregnant and lactating women and children 0–5 years of age had priority for essential foods for mineralization. It has been assumed that the intake of calcium, phosphorus, iron and vitamins A, B_1, C, and D by these groups was sufficient to meet their needs. Except for pre-school children, the diet was very low in fat and probably somewhat low in carbohydrates, particularly for the older school children. Total calories, also, were insufficient for older children. For all persons, the sugar supply was less than one half of pre-war consumption; and all candy was practically eliminated. Bread was made of 95 per cent extraction flour. Consumption of fish, potatoes, and root vegetables increased.

After the War a gradual change towards pre-war food conditions took place. It may be assumed that the food eaten by pregnant and lactating women and children above 2–3 years of age did not contain as liberal amounts of vitamins A and D as during the War. (*See* Tables 39–43.)

8. *Causes of the Decrease and the Subsequent Increase in Caries Rates.* The change in mouth environment brought about by the drastic reduction in consumption of sugar and sugar products during the war years has to be considered the main cause of the reduced caries rate. Particular stress should be put on the disappearance of all kinds of candy and sugar-sweetened cookies and cakes usually taken between meals. More liberal use of root vegetables, which acted as a tooth cleanser, no doubt, also played a role. The coarse flour, too, may have had some effect.

An increased tooth resistance seems to have acted as a second factor. This increased resistance may be due chiefly to more favorable conditions for the earliest posteruptive maturation of the enamel surface.

The post-war increase in the caries rate must be ascribed chiefly to gradual changes towards pre-war consumption of foods that tend to leave carbohydrate deposits on the teeth, and, particularly, to the frequent eating of such foods.

9. Reports from some other countries on caries rates in

children and food conditions during World War II have been reviewed. In war-torn countries with restrictions on food consumption, decreased caries rates during the War were observed very generally. The magnitude of the decrease seems to be correlated chiefly with the restriction in sugar and sugar products. Most of the reports corroborate, in the main, our findings and conclusions from the studies on Norway.

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ERRATA

The caption to Figure 27 should read: "Percentage of total surfaces DMF in specific teeth at age 13 years for boys and girls in cities, 1940–1941 to 1948–1949."

That for Figure 28 should read: "Percentages of total surfaces DMF in specific teeth at age 13 years for boys and girls in Gjerpen, 1940–1941 to 1948–1949."

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